DIESEL MECHANICAL

MULTIPLE UNITS

MOTIVE POWER
TRAINING SCHOOL

GENERAL MANAGER
BRITISH RAILWAYS
SOUTHERN REGION
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DIESEL MECHANICAL MULTIPLE UNITS.

General Description

Diesel Mechanical Multiple Units (Rail Cars) are designed to run in sets comprising power vehicles and trailer/s. Engines and transmissions are provided only on the power cars, and arrangements are made to enable up to a maximum of six power cars and three Trailers to be coupled together and driven from the driving cab of the leading vehicle.

All power cars are provided with a diesel engine and transmission system for each of the two bogies of the car, and where a power car and a trailer are run as a set, the trailer car will have a driving compartment.

The equipment for transmission on a power car consists of the:-

Diesel Engine - which is arranged horizontally below the under-frame is of the six cylinder, 4-stroke, single-acting, 150 B.H.P.type Each engine is fitted with a 20" fluid coupling bolted to the engine flywheel and with a special grade of lubricating oil. This coupling is designed to take up all starting slip, thus reducing wear and tear on the engine and transmission units as well as making it impossible for the driver to stall the engine as a result of overloading or careless manipulation of the controls.

The Freewheel - this is an overdrive protection which ensures that when the gearbox input shaft is rotating faster than the engine output shaft, i.e. when coasting, the Freewheel will slip and protect the engine from overspeeding. Therefore, when coasting the throttle can be returned to the idling position.

The Gearbox - this is a Wilson 4-speed constant mesh type epicyclic gearbox, and gear selecting is effected by compressed air.

As it is essential in Railway traction for units to have all gears available when moving in either direction the transmission includes a -

Reverse and Final Drive Unit.

This unit is mounted directly on the driving axle of the Power Car Bogie which is the inner of the two axles. The Reverse and Final Unit has three functions.-

(i) To transmit the drive to the driving axle.
(ii) To provide a means of reversing the direction of travel.
(iii) To provide a means by which the drive can be isolated from the transmission.

Control of the Forward or Reverse selection is by compressed air.

Control.

Power cars are designed to be driven from a control desk on the left-hand side of the driving cab, with all the necessary gauges and controls conveniently grouped. Provision has to be made to start the diesel engines, to control simultaneously all the equipment on the train; to drive it in either directions; to provide efficient braking, and whilst driving, to control the performance of the engines. Provision is also made for all the foregoing to be controlled from a driving trailer.

This control is obtained from the auxiliary equipment which comprises the following:-

Batteries

These are used to start the diesel engines, store electrical energy, light the train and operate the Fire Alarm warning system. The batteries are charged when the diesel engine is running by a -

Generator which is belt driven from the output shaft.

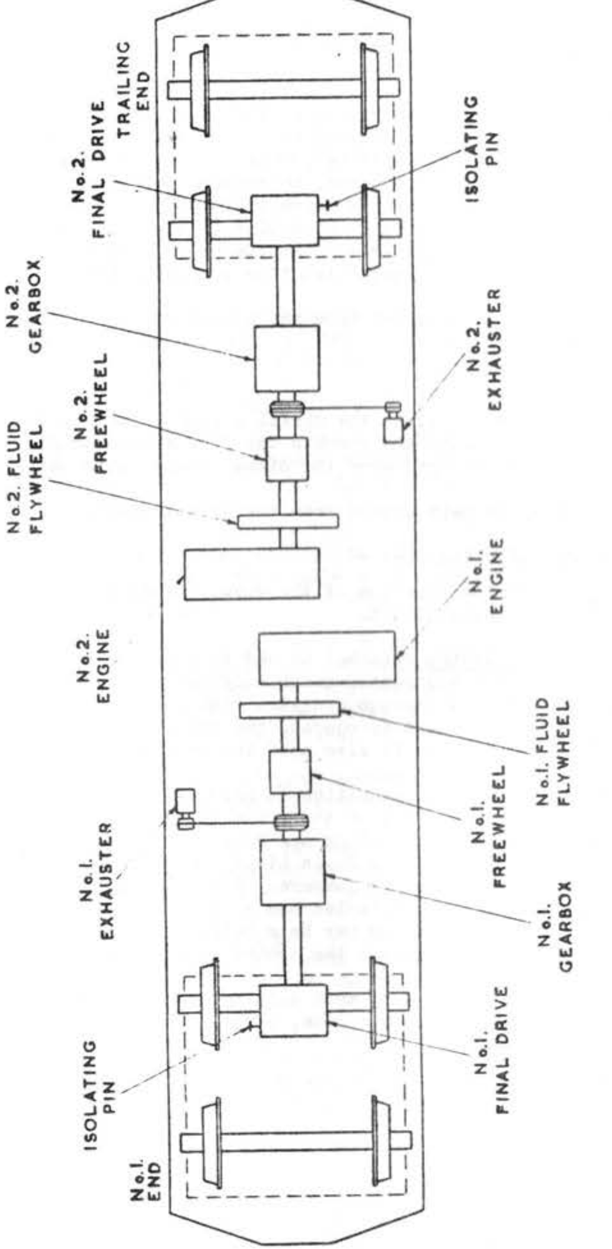
The equipment also includes -

An Exhauster for the creation of the vacuum brake which is belt driven from the Cardan Shaft.

A Compressed Air System attached to and gear driven by, the diesel engines is a compressor which supplies air under pressure to the air reservoirs through pressure regulating and unloading valves. The air is used to operate the throttle, gear, and final drive pistons, and is also used for pneumatic horns.

Couplers and Jumpers Connection is provided between the driving cabs of a unit and the rest of the train to ensure that the power equipment can be controlled from one cab. This connection is achieved within the units by Train Lines and inter-coach couplers, and between units by Control jumpers. Signs are painted on the body above the jumper receptacles and also on the jumper cables and receptacles, these signs may be a yellow diamond, red triangle, or blue square, and indicates the control system used.

Cars must only be electrically coupled to other cars of the same colour code, using jumpers of the same code.



POWER TRANSMISSION LAYOUT FIG 1

TECHNICAL DATA.

Type 2-2-2-2 (1A-A1).		Power Car.		Trailer.
Weight in running order.		37 tons.		31 tons.
Tractive Effort (Single Power Car)	1 gear 6,570 lbs	2nd 3,710 lbs	3rd 2,420 lbs	4th 1,610 lbs
Max. speed at max. engine revs.	15.3 mph	27 mph	41 mph	65.5 mph

Wheel base. (Bogie)	8' 6"
Wheel diameter.	3'
Width overall	9' 3"
Length overall	198' 9"
Height overall	12' 8"
Minimum curve negotiable.	3½ chains.
Fuel capacity:-	88 galls. engine (separate tank 35 galls coach heating)

Engines :- B.U.T. Leyland Type. Leyland-Type 680/1 150 b.h.p.
Two six cylinder horizontal oil engines. at 1,800 revs.

Compression Ratio	15.75 to 1.
Bore	5.00 ins.
Stroke	5.75 ins
Firing Order	1,5,3,6,2,4,
Fuel injector type	Leyland M41.
" " lifting pressure	2,657 - 2,130 lbs p.s.i.
" " pump type	C.A.V. Monobloc.

A.E.C. Type.
two six cylinder horizontal oil engines. A.E.C. Type 220 AC. 150 b.h.p. at 1,800 revs.

Compression Ratio	16 to 1.
Bore	5.12 ins.
Stroke	·5.5907 ins
Firing Order.	1,5,3,6,2,4.
Fuel injector type.	C.A.V. B.D.L. L. 150s
" " lifting pressure.	2,570 lbs. p.s.i.
" " pump type	C.A.V. Monobloc

Transmission Type :-	Fluid Coupling. Wilson Type. 4-speed epicyclic (electro-pneumatic operated). Axially sliding dog clutch between bevel gears incorporated in final drive gearbox.
Batteries : Blue Square cars.	12 Lead acid 24 volts.
Generators.	Belt driven
Starter Motors.	Simms or C.A.V. axial type.
Compressors.	Clayton Dewandre C.D.Series 2⅞" x 1⅝" Type P.C.G.A. 189 Gear driven from A.E.C. engine. Westinghouse type 246. Gear driven, from Leyland engine.
Exhauster.	Clayton Dewandre. Type C.725. Belt driven.

DRIVER'S CONTROLS.

1. Electrical control switch. (Car type with removable key).
2. Throttle handle (engine speed) incorporating Deadman's device.
3. Change gear selector lever.
4. Reversing lever (detachable)
5. Engine "start" buttons.
6. Engine "stop" buttons.
7. Engine indicator lights.
8. Air pressure/Final drive direction indicator lights.
9. Engine Tachometer/Change Speed indicator.
10. Dual horn control.
11. Speedometer.
12. Air pressure gauge.
13. Vacuum gauge (Duplex).
14. Driver's brake valve. (Detachable handle).
15. Headlight switches.
16. Windscreen wiper control.
17. Instrument light switches and dimmer.
18. Changeover switch, engine speed.
19. Route indicator switch.
20. Buzzer and button.
21. Handbrake.
22. Deadman isolating valve.
23. Car heater switches.
24. Deadman holdover button.
25. Car and train light switch.
26. Fire alarm bell.
27. Demister fan switch.
28. Passenger emergency re-setting valve, on each side of cab, applicable to each car only.

DESIGN AND CONSTRUCTION OF HIGH SPEED DIESEL ENGINE

B.U.T. - A.E.C. "A" TYPE AND LEYLAND "L" TYPE ENGINES.

These are both six cylinder, four stroke, single-acting naturally aspirated engines and except for variations in lay-out are basically the same.

The engine is mounted horizontally beneath the framing. The engine casing, which is the main component, is divided vertically at the crankshaft centre line, it comprises a cast cylinder block and crankcase to which and engine casing extension and sump are bolted.

Cylinder liners are of the renewable type.

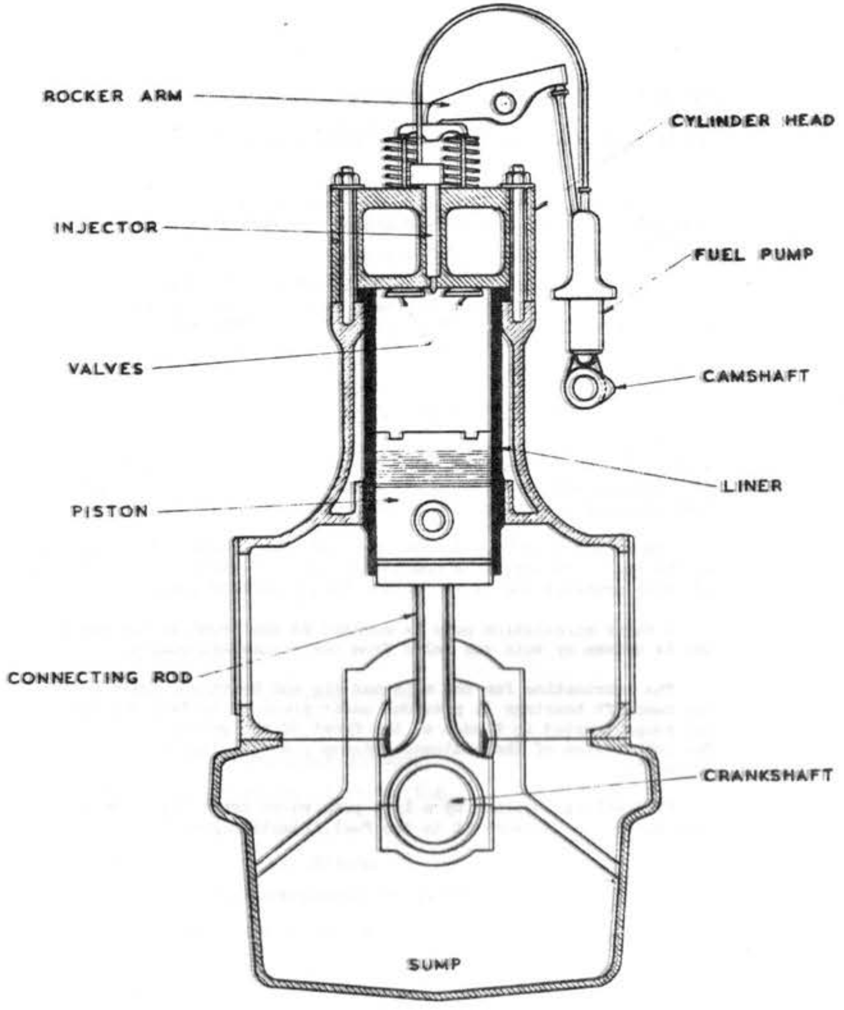
Two detachable cylinder heads are used, each covering three cylinders. There is one exhaust and one inlet valve per cylinder and these, together with the valve rocker gear and fuel injectors, are carried in the cylinder heads.

The rocker gear is push-rod operated from a camshaft located in the engine casing, this camshaft is gear driven from the crankshaft and also provides the drive for the fuel injection pump.

A water circulation pump is mounted at the front of the engine and is driven by twin vee belts from the crankshaft pulley.

The lubrication for the main and big end bearings, valve gear and camshaft bearings is provided under pressure by two gear-driven oil pumps mounted in tandem at the front of the engine.
The lubrication of the pistons, gudgeon pins and tappets is by 'splash'.

Fuel oil is supplied by a lift pump which draws fuel from the main tanks and delivers it to the fuel injection pump.



CROSS SECTION OF A TYPICAL 4 STROKE DIESEL ENGINE
FIG 2

FOUR STROKE CYCLE.

It is well known that when air is compressed its temperature rises and if the compression be high enough, the resultant temperature suffices to ignite readily the liquid fuel charge. This is the principle of the compression ignition engine, to repeat, ignition is effected solely by the temperature of the compressed air charge.

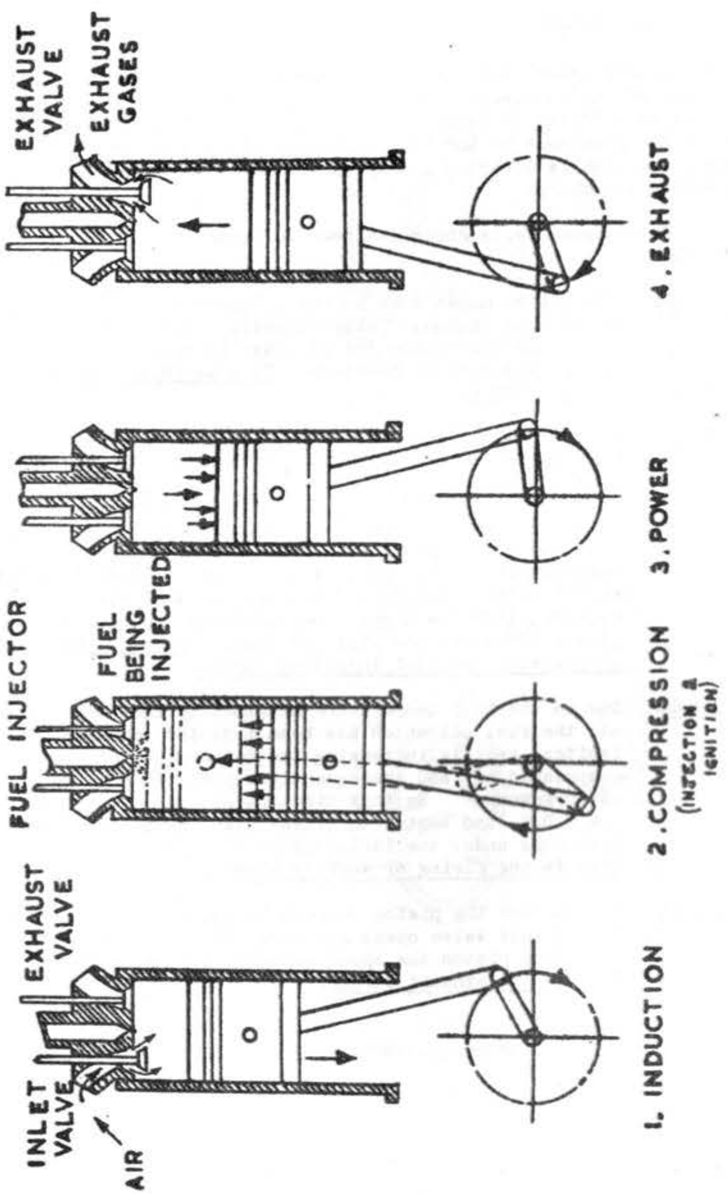
The four stroke cycle comprises four definite periods and are as follows:-

1st Stroke — The piston moves down in the cylinder with the inlet valve open (Exhaust Valve closed). During the first stroke of the piston the cylinder becomes filled with air at atmospheric pressure. This is Induction or Suction Stroke.

2nd Stroke — The air inlet valve closes and the piston begins to move up the cylinder comprising the air which has been drawn in on the previous stroke. As the piston approaches Top Dead Centre (T.D.C.) the air pressure is increased to several hundred pounds per square inch. This rapid compression has the effect of raising the temperature of the air to a high degree. Just before the piston reaches T.D.C. a fine spray of fuel oil is injected into the highly compressed air between the piston crown and the cylinder head. This is the compression and Fuel injection stroke.

3rd Stroke — Due to the high temperature attained by the compressed air the fuel oil which has been injected immediately ignites, rapidly increasing the temperature of the compressed air and consequently rapidly increasing the air pressure. By this time the piston has passed the T.D.C. and begins to travel down the cylinder and continues under the influence of the expanding gases. This is the firing or working stroke.

4th Stroke — Just before the piston reaches bottom dead centre (B.D.C.) the exhaust valve opens and under the influence of the ascending piston the spent gases are driven out. This is the exhaust stroke.



FOUR STROKE CYCLE SINGLE ACTING FIG 3

ENGINE SPEED CONTROL.

Fuel supply to the cylinders is regulated by a throttle motor which consists of four air pistons all acting upon a common shaft, which is connected by linkage to the fuel rack in the pump. Each piston turns the shaft further than the preceding one, thus opening the fuel rack and increasing the fuel supply.

The air supply to the four pistons is controlled by four E.P. (electro-pneumatic) valves which are energised from the battery via the Driving cab Throttle control and 4 train lines.

There is no "Engine Stopped" position in the throttle motor as the closed position is that in which the engine idles.

The positions of the throttle control handle are:-

IDLING (Released) — The handle is released and sprung upwards. The Deadman's valve and gearbox valves are de-energised, therefore, the gears will be "Neutral", irrespective of the gear selector handle position.
The "E.P." valves in the throttle motor are also de-energised, therefore, the engines will be "idling".

IDLING (Depressed) — The throttle handle is depressed and only the Deadman's valve and gear box valves are energised. Engines "idling".

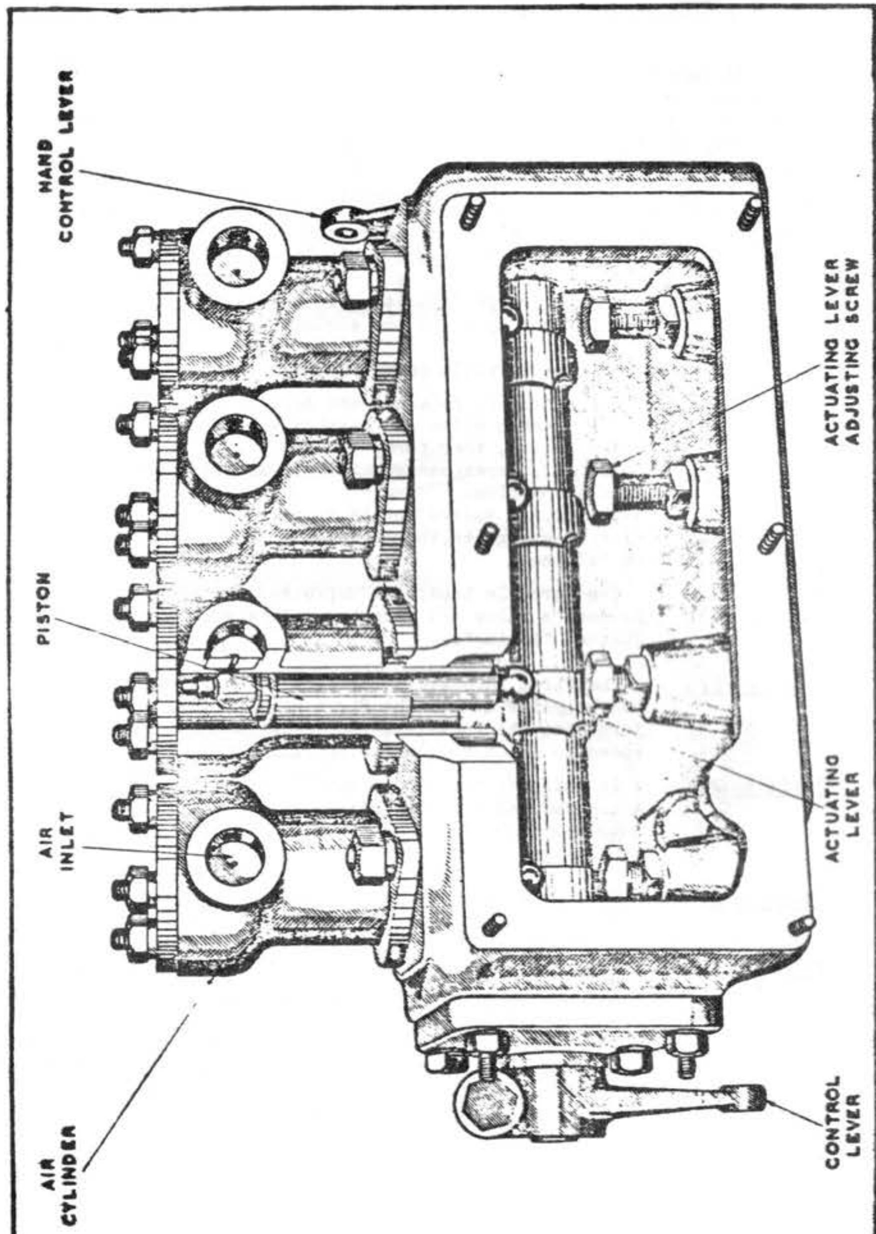
Position 1. — The first throttle motor E.P. valve is energised and supplies air to the first piston, this will in turn open the fuel rack and increase the engine speed to about a quarter of full speed.

Position 2. — In this position the second E.P.valve is also energised and both one and two pistons are not supplied with air. Fuel supply and engine speed are again increased.

Position 3. — Nó.1 E.P. de-energised. Nos. 2 and 3 now energised. Further increase of fuel and engine speed.

FULL — No.2 now de-energised. Nos.3 and 4 energised.

The engine will now increase to maximum revolutions (1800 r.p.m.)
The wires from the throttle control handle to the E.P. valves are train wires which run the length of the train via the jumpers, therefore, the throttle motors on all power cars operate simultaneously.



THROTTLE MOTOR FIG 4

THE ENGINE TWO-SPEED GOVERNOR.

This controls the revolutions of the diesel engine and is a mechanical governor, using the principle of flyweights, this ensures "idling speed" when the throttle is closed, and a maximum speed which will not damage the engine.

The movement of two flyweights which are mounted on the injector pump camshaft, is restricted by springs. These will restrain the weights until idling speed is reached but should the idling speed rise above the normal (680 r.p.m.) centrifugal force acting on the weights will overcome the springs and allow the weights to move outwards. Bell crank levers attached to the weights will then move the pump control rod towards the "stop" position, thus reducing the supply of fuel. Should idling speed fall below normal the reverse action will take place.

Between the idling and maximum speeds the engine is controlled directly by the throttle control handle and the flyweights are restrained by two outer compression springs until these springs are compressed, at which time the weights will again take control. This point will give the predetermined maximum revolutions.

The engine can be stopped by operating an electric solenoid, mechanically connected to a stop lever on the side of the governor, which when operated will move the pump control rod to the "no fuel" position.

FUEL SYSTEM AND INJECTION.

It has been previously mentioned that the performance of the engine is related to the amount of fuel which can be burnt in the cylinders, and that the amount of fuel is proportional to the quantity of air which is induced into the cylinders during the Induction stroke. The air contains oxygen for combustion and too little oxygen will result in incomplete combustion and black smoke at the exhaust.

The heat produced by compressing the air in the cylinder during the compression stroke, is capable of firing the fuel. Due, however, to the very short time available in which to burn the fuel, it is necessary to ensure that it burns rapidly. This is done by injecting the fuel into the cylinder as a very fine spray (or."atomised" and mixes quickly and thoroughly with the air in the cylinder.

Fuel is stored in tanks slung under the frame and each tank is fitted with a filler and contents gauge.

Fuel System.

In the typical layout shown it will be seen that fuel is drawn from the tank by the fuel feed pump via a Primary Filter and is delivered by way of the Secondary filter to the injection pump gallery. The secondary filter is fitted with a pressure relief valve which returns surplus fuel to the tank.

Fuel Feed Pump

The purpose of the fuel feed (of Lift pump) is to draw the fuel from the tank and deliver it to the Injection Pump and is usually bolted directly to the Injection Pump. The diaphragm of the left pump can be hand operated by the priming lever provided for this purpose.

Injection Pump

The injection pump having been fed with fuel by the Feed or Lift Pump, must now deliver it to the injectors. An injection pump is a precise piece of equipment which accurately controls the amount of fuel and delivers it at the given instant with the steady pressure necessary to lift the injection needle valve.

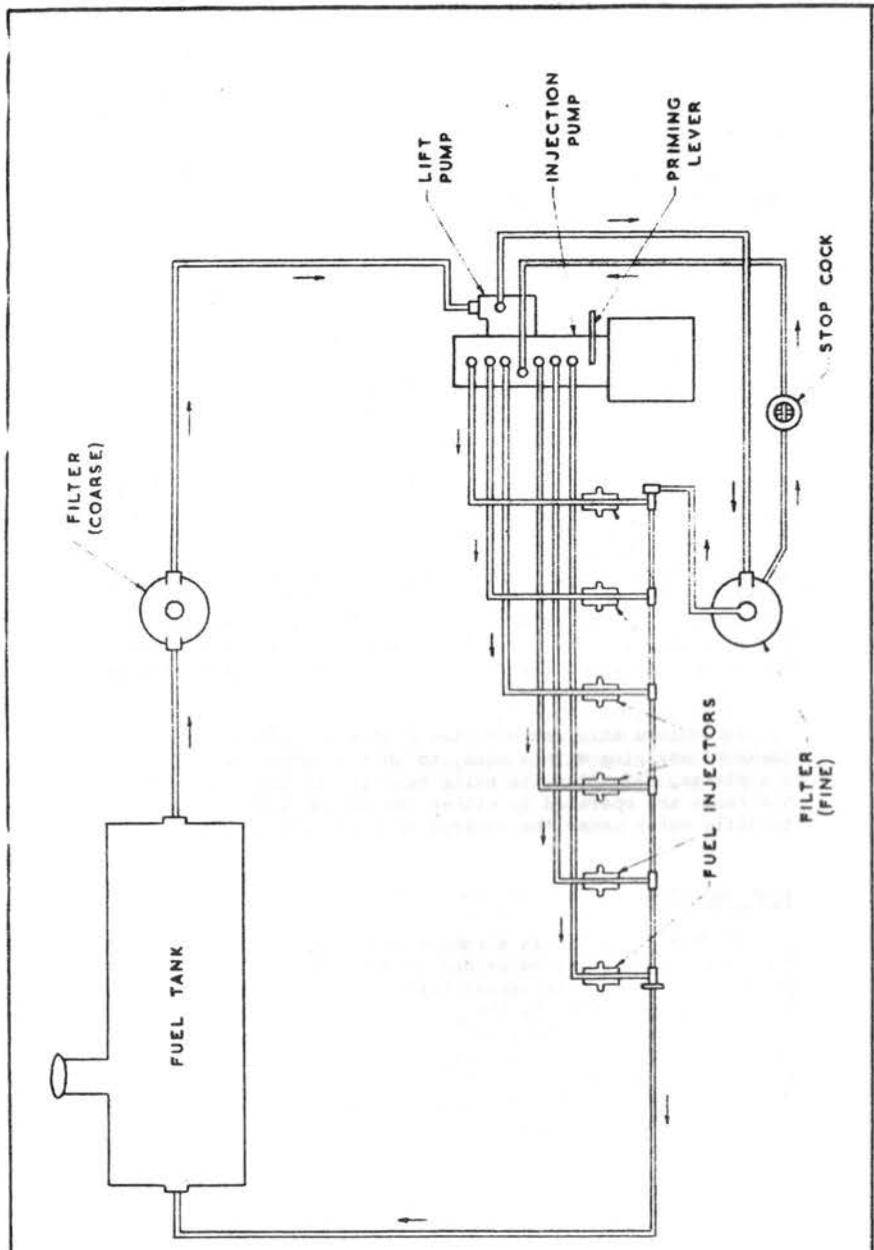
The injection pump consists of a cylinder with a non-return valve in the head. A spring loaded ram or piston with a helical groove cut in it works in the cylinder by the action of a cam geared to the crank shaft. When the piston is at the bottom of its stroke it exposes a port through which the fuel oil enters. As the piston rises it closes the inlet port and the fuel oil is compressed and forced past the non-return valve and hence to the injector. Injection continues until the helical groove uncovers the port and allows the oil to escape or spill from above the piston, so reducing the pressure. After the pumping stroke, the piston is returned to the bottom of its stroke by a return spring.

It will be seen that the piston stroke is constant and determined by the lift of the cam, but the quantity of fuel delivered per stroke must be capable of adjustment to provide control over the power output of the engine. This is done by varying the fuel overflow or spill port timing by altering the position of the helical groove in the piston in relation to the port, and so governing the period of injection on each stroke. Thus when the piston is turned so that the spill port is covered for the whole stroke, injection is taking place for a longer time and more oil is being injected than when the spill port is closed for only a small portion of the stroke.

To achieve this rotation the piston is fitted with a toothed quadrant engaging with a rack, so that movement of the rack turns the piston, adjusting its helix relative to the spill port. the racks are operated by either the Engine Speed Governor or the throttle motor under the control of the Driver's throttle lever.

FUEL INJECTOR

The Fuel Injector is a robust unit, capable of withstanding the 2540 p.s.i. pressure needed to force the fuel oil into the cylinder. It consists essentially of a spring loaded needle valve which is lifted by the pressure of the fuel oil. In order to deliver the fuel oil to the right place in the cylinder the nozzle of the Injector protrudes into the combustion space, which is the hottest point in the cylinder. The fuel oil is forced through several extremely small holes drilled in the end of the Injector which atomise it on delivery.



FUEL SYSTEM FIG 5

LUBRICATING OIL SYSTEM.

B.U.T. LEYLAND "L" TYPE ENGINE.

An engine driven pump draws the lubricating oil from the sump via a suchtion filter and passes it at a pressure of 60 p.s.i., through a cooler and into the main oil gallery which is drilled in the engine casing, then through branches to the Main Crankshaft and Camshaft Bearing.

From the Main Bearings it passes through passages in the Crankshaft to the Big End Bearings from which a splash feed lubricates the cylinder walls and small end bearings. The oil then drains back to the sump. A branch from the main gallery supplies oil to lubricate the timing gear, and also the air compressor on the top of the engine.

A feed supply from the second and fifth camshaft bearings is used to lubricate the valve gear mounted at the top of the engine in two cylinder heads each covering three cylinders. The oil is fed through the centre bracket of each set of valve gear, through channels to the bearings, valve guides and so back to the sump.

An oil pressure switch is fitted at the end of the main gallery, which will illuminate the engine light in the cab when pressure is normal. It is also fitted to the engine shut-down solenoid and will cut off the fuel supply should the oil pressure drop below a safe minimum.

B.U.T. - A.E.C. "A" TYPE ENGINE

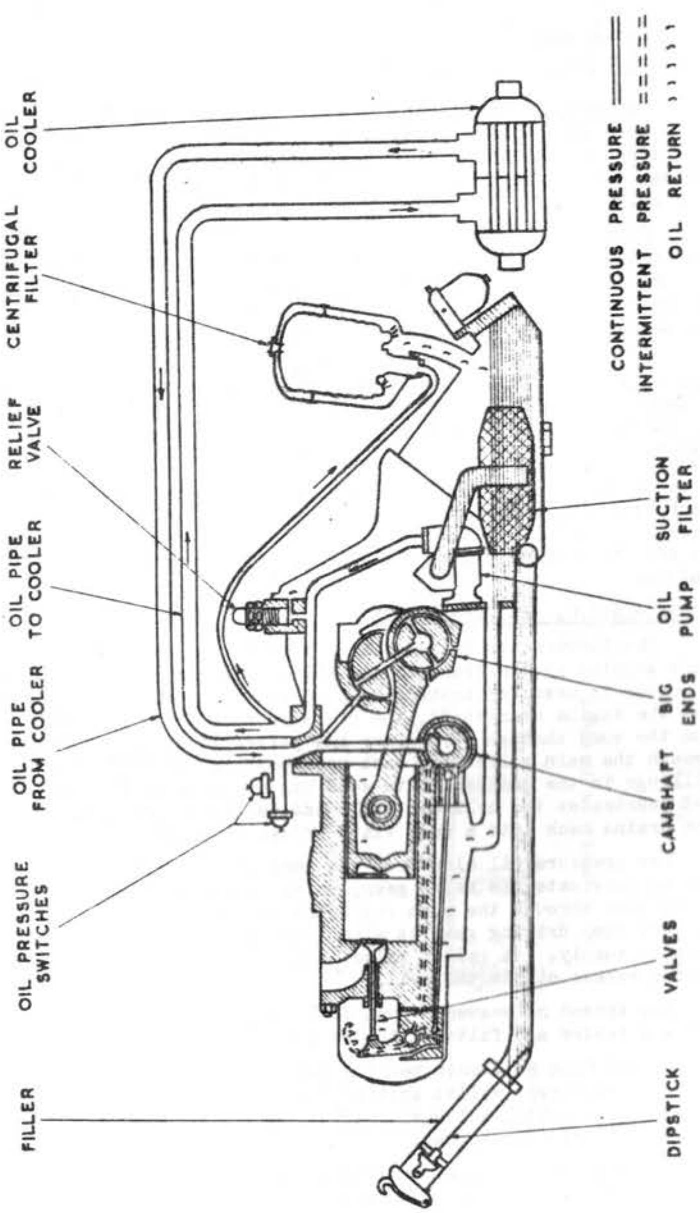
The lubricating oil system on this engine employs two gear type pumps mounted at the front of the engine, one is a pressure pump, the other is used for scavenging purposes. Both pumps are gear driven from the engine crankshaft, the pressure pump draws lubricating oil from the sump through a strainer and passes it at a pressure of 60 p.s.i. through the main gallery to each main bearing, it will also pass through drillings in the crankshaft to each big end bearing from which a splash feed lubricates the cylinder walls and small end bearings. The oil then drains back into a well via a trough in which the camshaft runs.

Low pressure oil bled from the pump at approximately 5 p.s.i. is used to lubricate the valve gear, valve spindles and guides. It then passes down through the push rod holes to the camshaft and well. The fuel pump driving gear is also lubricated by a branch from the low pressure supply. A relief valve maintains pressure at 60 p.s.i. and returns excess oil to the well.

The second or scavenge pump draws the oil from the well and passes it via a cooler and filter into the sump.

A feed from No.1 main bearing carried lubricant to the timing gear and compressor whilst another feed is taken from No.4 main bearing to a pressure switch which will illuminate the engine light in the cab when oil pressure is normal.

On some A.E.C. engines a second pressure switch will operate the engine shut-down solenoid and close the fuel racks in the event of lubricating oil pressure dropping below a safe minimum.



LUBRICATING OIL SYSTEM FIG 6

WATER COOLING SYSTEM.

To control the very high temperature created in the diesel engine, water is circulated around the cylinders and cylinder heads and the excess heat is absorbed by the water. The engine temperature is therefore maintained within certain limits thus enabling the engine to work at its maximum efficiency.

This is achieved by passing the water through a radiator which consists of an upper and lower tank connected by several finned tubes or elements.

An engine driven centrifugal pump takes the water from the water from the bottom of the radiator and circulates it round the engine water jackets. After absorbing the heat the water is passed to the upper tank of the radiator and down through the elements at which time the heat is extracted by cooling air flowing through the fins. The cooling effect is increased by the action of an engine driven fan which increases the flow of air through the radiator.

It is essential that the engine and radiator are kept full of water and losses due to evaporation are replaced, therefore, a header tank for each engine is provided in the car.

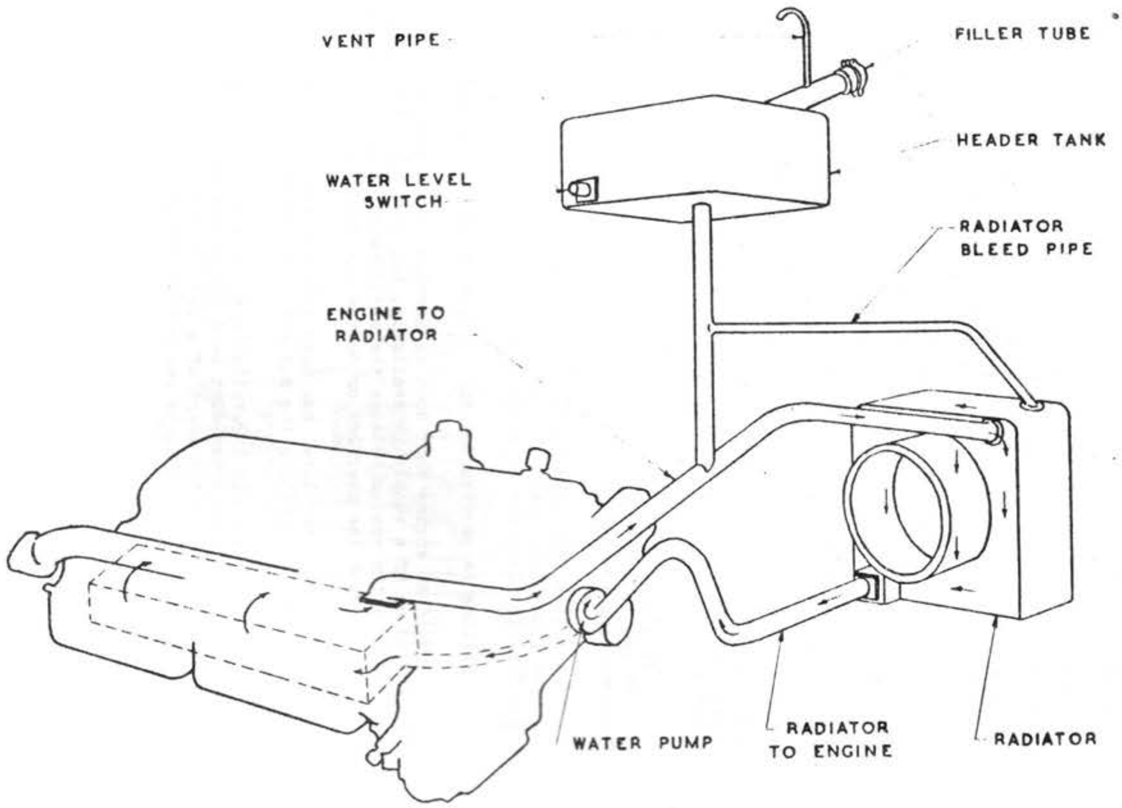
A switch tank containing a Mobrey Float Switch is also fitted, (below floor level) and this device will stop the engine by cutting off the fuel in the event of a low water level.

Filling is carried out via a filler pipe at the side of the car.

Should an engine shut down in service due to lack of water it can be topped up if a supply is available, but care should be taken not to overfill the system because the anti-freeze solution could be washed out with the overflow or become extremely diluted.

After the water level has been restored the engine trip switch must be re-set by pulling the rod until it latches.

If no water supply is available and the engine cannot be restarted, the final drive must be isolated before the train is worked forward. In the event of a radiator being topped up while in service it should be reported immediately on arrival at the Home Station.



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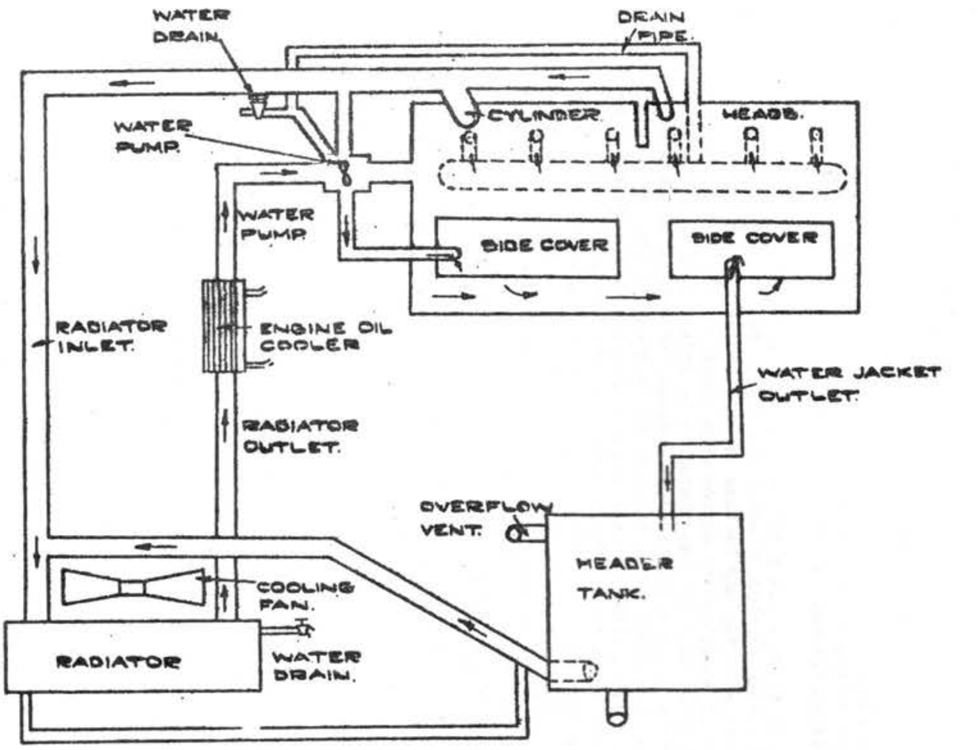
WATER COOLING SYSTEM "A" TYPE FIG 7



WATER COOLING ('L' TYPE ENGINE) FIG 8

THE VULCAN SINCLAIR HYDRAULIC COUPLING.

DESCRIPTION.

It must be remembered that any vehicle having a mechanical drive from engine to driving axle must have some device such as a clutch to disconnect the engine from the axle when necessary. On these units a fluid or hydraulic coupling is provided, known as a rigid traction type. It is bolted to the crankshaft, spigoted and registered to it to ensure concentric running.

The coupling is also designed to take up all starting slip, to absorb torsional vibrations and to protect the engine and transmission against buffing and drawbar shocks.

It is in no sense a torque converter but functions purely as a fluid clutch capable of absorbing a high degree of slip for short periods at starting and because of this characteristic it eliminates all risk of stalling the engine when taking up the load.
The hydraulic coupling can therefore be looked upon as a clutch in which there is no actual contact between the driving and driven elements, the power being transmitted from one to the other by oil. It is not susceptible to wear and engagement and disengagement is smooth and shock free. The efficient working range of the coupling when under is between 1100 r.p.m. and 1800 r.p.m. and in order to avoid excessive or prolonged slip and consequent overheating of the coupling, intelligent use of the change speed gearbox is necessary to ensure that when under load the engine speed is maintained within the speed range referred to above and the unit is driven in a gear which will enable the engine speed to be maintained and for which an engine tachometer is provided on the instrument panel.

CONSTRUCTION.

The coupling is comprised of three main components:-

(a) A casing or flywheel
(b) An impeller or driving portion
(c) A runner or driven portion

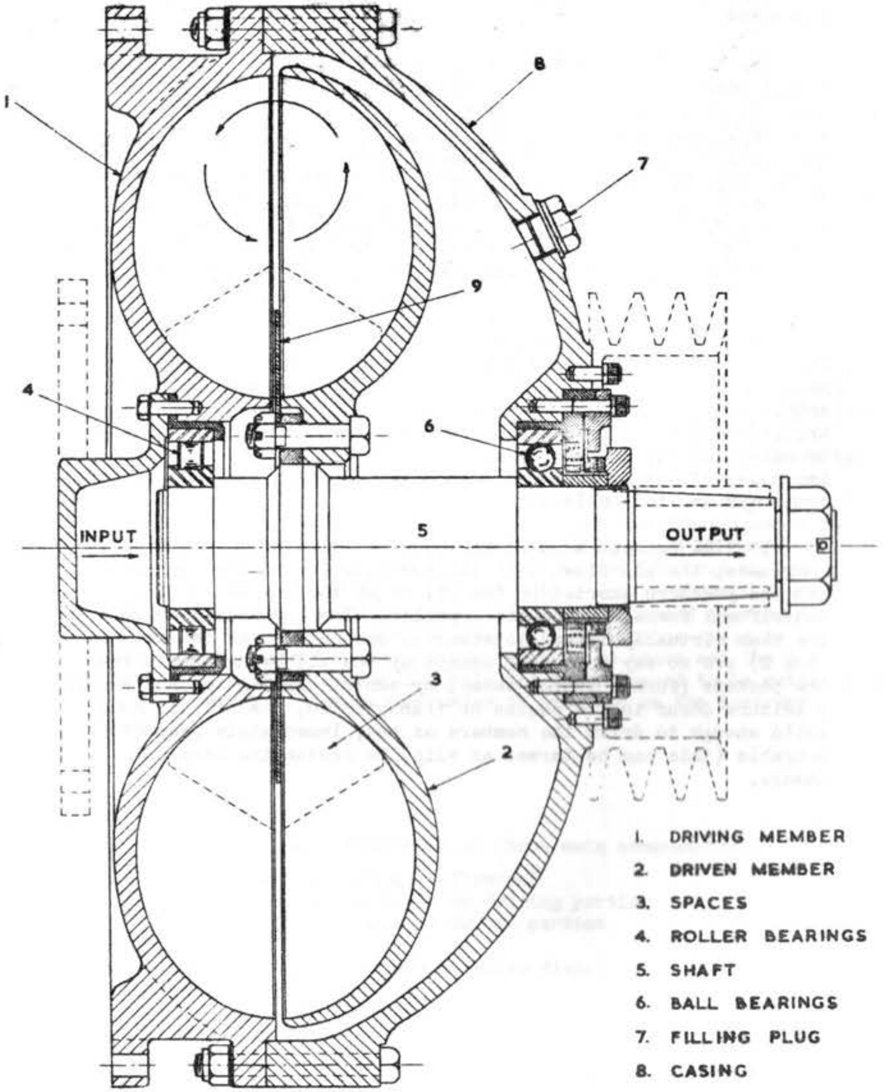
both impeller and runner are circular dished components provided with straight radial vanes.

PRINCIPLE

The driving (1) and driven (2) members are equipped with radial webbs on their inner surface contained in a casing (8) which is filled with lubricating oil to the level of the uppermost plug (7) the capacity being approximately 4½ gallons. The fluid coupling is then an automatic clutch and transmit power to the driving shaft (5) relative to the speed of the diesel engine. The working depends on the impellar imparting kinetic energy to the oil as it flows outwards under the influence of centrifugal force (see arrows in illustration showing direction flow) and the runner extracting kinetic energy from the oil as it flows inwards again and loses velocity.

Due to the difference in speed of the impellar and runner the oil flows in a spiral path within a closed loop, (known as a vortex), thus applying load to the radial vanes and hence torque to the output shaft. At engine idling speed the coupling does not transmit power but a small increase of engine speed is sufficient to cause the fluid coupling to take up gradually and further increases of engine speed will ensure full transmission of power, or torque as it is called.

It will be seen that as the speed of the driving member (1) increases, the oil flows into the cavities of the driven member (2) and the pressure exerted by the oil under the influence of centrifugal force rotates the impellar. The impellar and runner are then virtually locked together as one unit. The two members (1 & 2) are no way connected except by the oil being forced into the pockets (formed by the vanes) by centrifugal action and should a seizure occur in the engine or transmission, the oil, although solid enough to drive the members as one, immediately becomes tearable (this can be termed as slip) to preventing serious damage.



VULCAN – SINCLAIR HYDRAULIC COUPLING
FIG 9

SLIP

There is, however, a difference in input and output speed, and this difference, since the torques are equal, is a measure of losses in the coupling. The difference in the speeds of the impellar (input) and the runner (output) is called slip. The fluid coupling is not subject to wear and tear like a normal friction clutch and cannot work out of adjustment. It does allow for slip to take place during normal working, but it must be remembered that a hydraulic coupling should not be allowed to run for long with a high degree of slip taking place since the slip represents energy being put into the oil and causing it to heat up.

The driver can avoid this happening by immediately disengaging gear to neutral just before the train comes to a stand. Although there is an 100% slip at idling, the pressure is reduced inside the coupling by a baffle which destroys the oil vortex at low speed, causing oil to flow via the spaces (3) in the vanes. Not all the oil circulates through the spaces in the pockets and this causes a slight drag in some instances by the runner (2) tending to turn.

FREEWHEEL COUPLING.

The freewheel coupling is fitted to allow the unit to coast without the transmission driving the diesel engine, and is fitted between the hydraulic coupling and the gearbox.

The driving shaft from the hydraulic coupling enters a housing known as the freewheel cage, and has on its outer circumference wedge shaped grooves. Laying in these grooves are roller bearings which, when the driving shaft is rotated are driven up hard against the outer casing, locking both into a solid unit.

When, however, the railcar is coasting and the throttle is closed, the outer casing will rotate faster than the inner driving shaft and the roller bearings will fall back into the grooves, allowing the transmission to overrun the engine without driving it.

When opening the throttle after coasting, care should be taken to increase engine speed one notch at a time to avoid any snatch occurring when the rollers again take up the drive.

WILSON-DREWRY EPICYCLIC GEARBOX.

The gearing consists of a number of gear trains made up of three elements (see diagram) which revolve round a common centre.

1. The Sunwheel
2. Idler gears or Planet wheels mounted on a carrier.
3. Annulus, which is toothed on its internal circumference.

As will be seen from the diagram, all the gears comprising the train are in constant mesh, and by connecting the elements of one train to those of another, different gear ratios can be obtained.

On the outer circumference of the annulus which acts as a brake drum, is placed a brake band with a lining of extremely hard wearing material which can be caused to grip the annulus thus stopping its rotation. The brake bands are centralised about the drums so as to prevent them rubbing when in the "Off" position.

Wear on the brake band linings is adjusted automatically by an:-

Automatic Adjuster:

This is a device which will reduce the effective length of the pull rod thus taking up the extra movement caused by wear on the brake linings.

The grip of the brake band is determined by the height of the thrust pad, which is in turn governed by the height of the thrust pad, which is in turn governed by the automatic adjuster nut.

Wear on the brake linings will necessarily allow the thrust pad higher movement thus the adjuster ring will strike the adjuster screw and be rotated anti-clockwise.

The adjuster ring is so pinned to the spring that this movement will loosen the spring from contact with the adjuster nut.

When the brake bandis released and the adjuster ring returns to the "Off" position, the tail will now strike the tail pin and be rotated in a clockwise direction, the adjuster spring will consequently grip the adjuster nut which will be screwed down, thus taking up movement caused by wear on the brake bands.

To ensure that the automatic adjustment of the epicyclic brake bands (i.e. on gears1, 2 and 3 not 4th) is maintained, the driver should carry out the following procedure once during each shift.
Check that the air pressure is at the maximum and stop engines.
Depress the throttle control to energise the gearbox E.P. valves; move the gear selector handle from Neutral through the gear and back to Neutral approximately six times,pausing in each gear for about 5 seconds to allow the mechanism to operate.
Should the air pressure drop to 65 p.s.i. during this operation the engines must be restarted and air pressure built up.

Operation of Gears.

When the first gear is engaged the brake holds stationary the first gear annulus (A1) so that revolution of the gear sunwheel (S1) which is connected to the input shaft, causes the first gear planets (P1) to roll round the internal teeth of the annulus, taking with them the first gear planet carrier (C1) in the same direction as the driving shaft, but at a lower speed. As the first gear annulus is held by the brake it also holds fast the planet carriers on the second gear and the annulus of the third gear. So the input shaft, annulus (A1), planets (P1), sunwheel (S1) and carriers to output shaft will be the items transmitting torque.

When the second speed is engaged the first gear annulus is released. The second gear annulus is held stationary, thus speeding up the first gear annulus (A1) through its interconnection with the second speed planet carrier (C2) and it will be seen that for this gear two simple epicyclic trains are combined together or compounded and the action is as follows:-

Items transmitting torque, first speed annulus is released and its train rotates as follows - Output shaft clockwise, sunwheel (S1) clockwise, planets (P1) anti-clockwise No.1 gear train is now rotating in a clockwise direction. Sunwheel (S2) clockwise, planets (P2) anti-clockwise, annulus (A2) no rotation.

A similar speeding up of the first and second gear annuli (A1 & (a2) is brought about by holding stationary the third gear sunwheel (S3) causing the planets (P3) to rotate round the sunwheel (S3). In this case, of course, the brakes on the first and second speed annuly are released. The action is as follows:- Items transmitting torque, output shaft rotating clockwise, No.1 gear train clockwise, comprising of annulus (A1) clockwise, planets (P1) anti-clockwise, sunwheel (S1) clockwise. No.2 gear train clockwise, comprising of sunwheel (S2) clockwise, planets (P2) anti-clockwise, annulus (A2) clockwise. Annulus (A3) clockwise, planets (P3) clockwise, sunwheel (S3) no rotation.

Top gear is obtained by means of a clutch which, when engaged, connects the 3rd speed sunwheel to 1st & 2nd gear sunwheel, therefore, locking the whole into a solid mass, which will revolve with the main shaft and give a direct drive.

The gear bos is used in conjunction with the fluid coupling on the engine, resulting in a combination affording a highly efficient mechanical transmission. The fluid coupling provides a smooth take-up from rest and 100% slip when the engine is idling and the Car is stationary with the train brake applied and the gears in Neutral.

Release of the brakes after engaging gear enables the drive to be taken up progressively as the engine speed is increased. Thus a gear can be engaged whilst the brakes of the train are applied without fear of stalling the engine.

WILSON-DREWRY EPICYCLIC GEARBOX. (CONTINUED)

Gearbox Air Pressure: air pressure at 65 p.s.i. is used to operate the gear train brake bands and it is essential that this pressure is maintained to prevent slipping of these bands.

Gearbox Lubrication : is provided by a gear type pump mounted on the front casing. It draws oil from the sump and passes it through an external pipe and filter to an oil muff where it is delivered to the gear trains and bearings. The gearbox capacity is approximately 2½ galls.

Coasting

All coasting must be done in fourth gear as this permits the whole gear train mechanism to be locked and revolve as a whole. This ensures that the gear box lubricating pump vacuum exhauster and generator continue to be driven via the road wheels and cardan shaft.

Forward and Reverse Final Drive.

Fitted to the input shaft inside the Final Drive casing are two bevel pinions which are free to rotate on the shaft i.e. they are not keyed but can rotate when the shaft is stationary. These bevel pinions are in constant mesh with the output bevel wheel which drives the axle through the reduction gear, and in the diagram it will be seen that the input shaft could be rotating whilst the road wheels and axle are at rest. To cause the wheels to turn it is necessary to connect the input shaft with either of the bevel pinions.

This is accomplished by means of a toothed dog which slides on the splined portion of the input shaft, engages with a bevel pinion, and locks it to the input shaft. The direction of rotation of the road wheels will be determined by which of the two bevel pinion is engaged by the dog.

The movement of the sliding dog is carried out by using two air cylinders, the pistons of which are connected by a rod to which is attached a striking fork, this fork will move the dog from side to side without restricting its rotation.

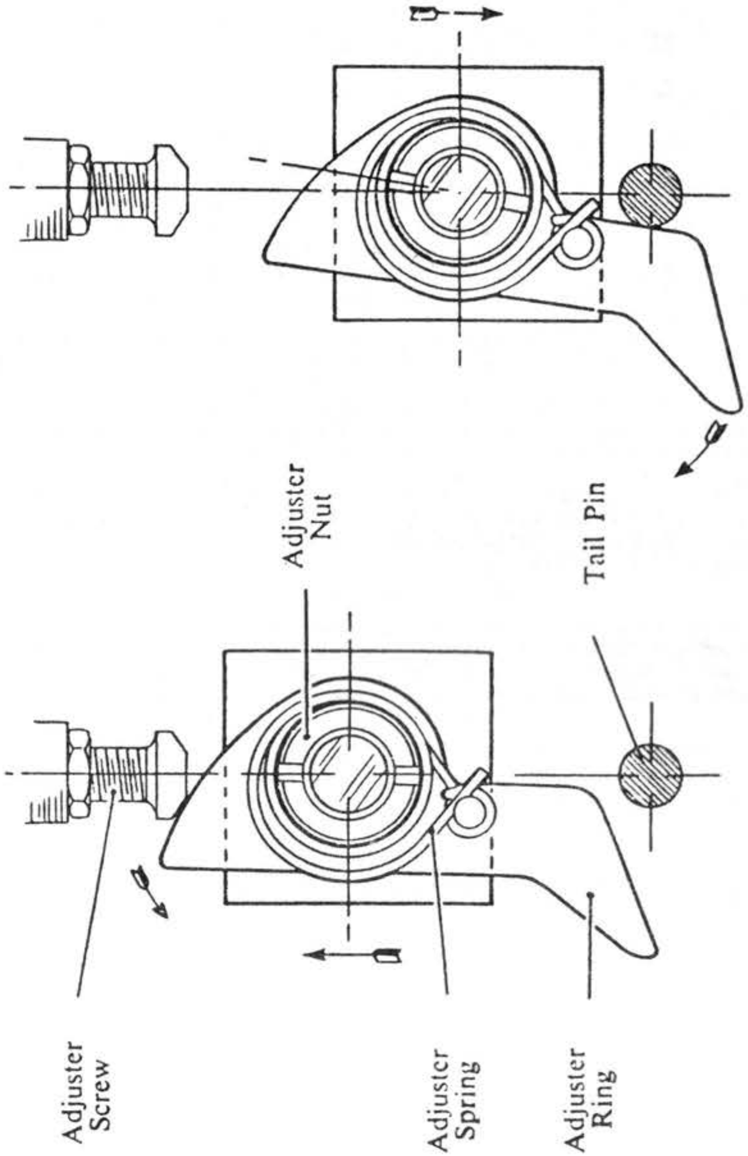
The driver, by use of the Forward and Reverse Lever, energises an E.P.valve which allows air into the selected air cylinder, thus selecting the direction in which the dog will move and consequently the rotation of the road wheels.

Forward and Reverse Final Drive. (Continued)

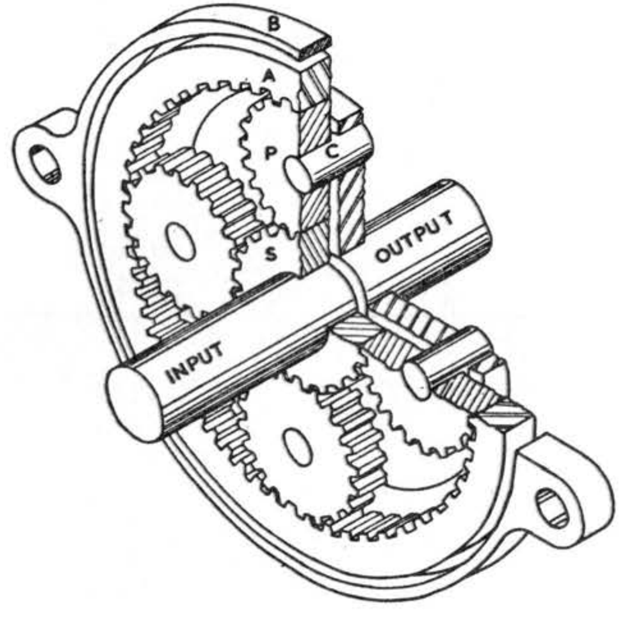
Air pressure is relied upon to hold the dog engages and to indicate to the driver that both final drives are in mesh according to the direction of the reversing lever, and "Air and Axle" light is illuminated (providing the air pressure is above 75 p.s.i.). This light should be checked every time the reversing lever is moved before starting the train. If the light fails to show after the lever has been operated, it should be moved to the opposite direction and back again.

Should an engine fail, the Final Drive must be locked in the neutral position using the manually operated locking pin, a fork for this purpose is carried in the Guard's compartment.
The isolating pin should be pulled from the shallow slot in which it rests to keep it clear of the slot in the piston rod, turned through a quarter turn and placed in the deep slot.

In order to get the pin engaged in the slot it may be necessary to move the reversing lever several times after releasing the plunger so that it engages with the slot as it passes from one side to the other.



OPERATION OF AUTO ADJUSTER FIG 10



S - SUN WHEEL, FITTED ON INPUT SHAFT.

P - PLANET GEAR, MOUNTED ON CARRIER.

C - CARRIER, FITTED IN FLANGE ON OUTLET SHAFT.

A - ANNULUS GEAR.

B - BRAKE, SHOWN IN 'OFF' POSITION.

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SIMPLE EPICYCLIC GEAR.
FIG 11

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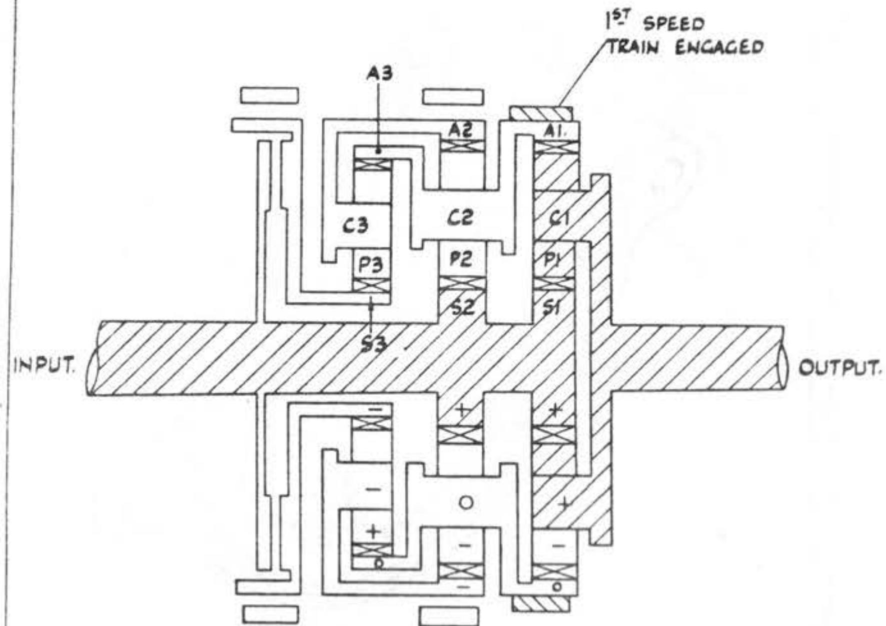


ITEMS TRANSMITTING TORQUE.

ITEMS NOT TRANSMITTING TORQUE.

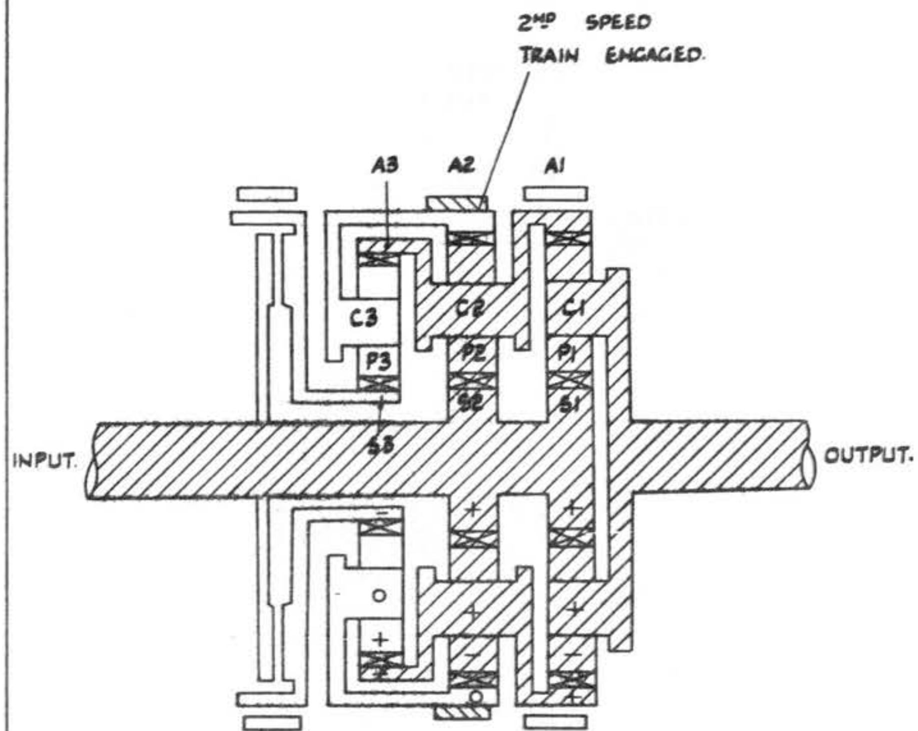
ROTATION.

+ CLOCKWISE LOOKING ON INPUT.

— ANTI-CLOCKWISE LOOKING ON INPUT.

O NO ROTATION.

EPICYCLIC GEARBOX.
1ST SPEED ENGAGED. FIG 12



ITEMS TRANSMITTING TORQUE.

ITEMS NOT TRANSMITTING TORQUE.

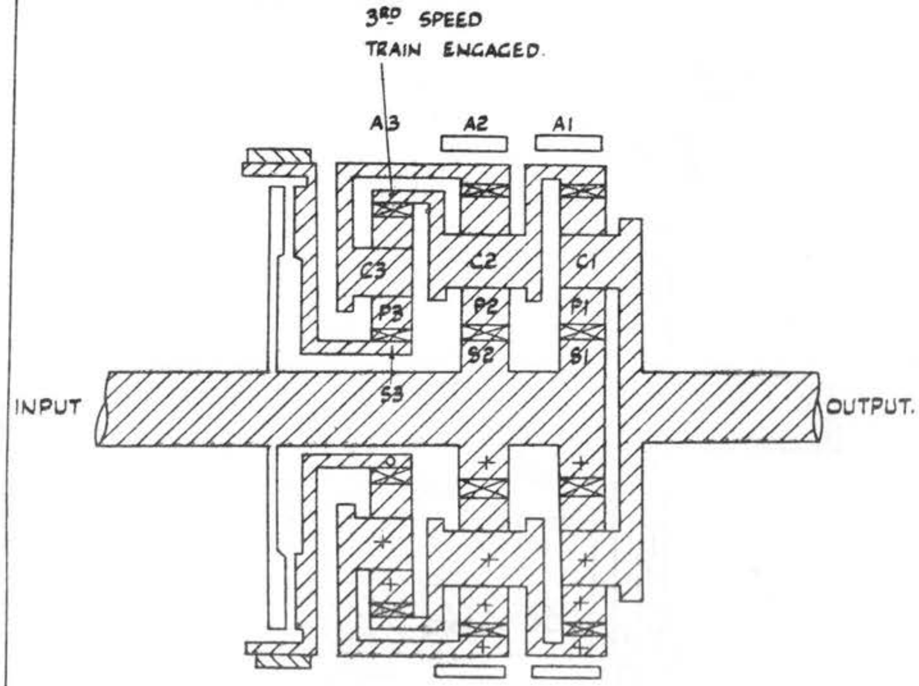
ROTATION.

+ CLOCKWISE LOOKING ON INPUT.

— ANTI-CLOCKWISE LOOKING ON INPUT.

O NO ROTATION.

EPICYCLIC GEARBOX.
2ND SPEED ENGAGED. FIG 13



ITEMS TRANSMITTING TORQUE.

ITEMS NOT TRANSMITTING TORQUE.

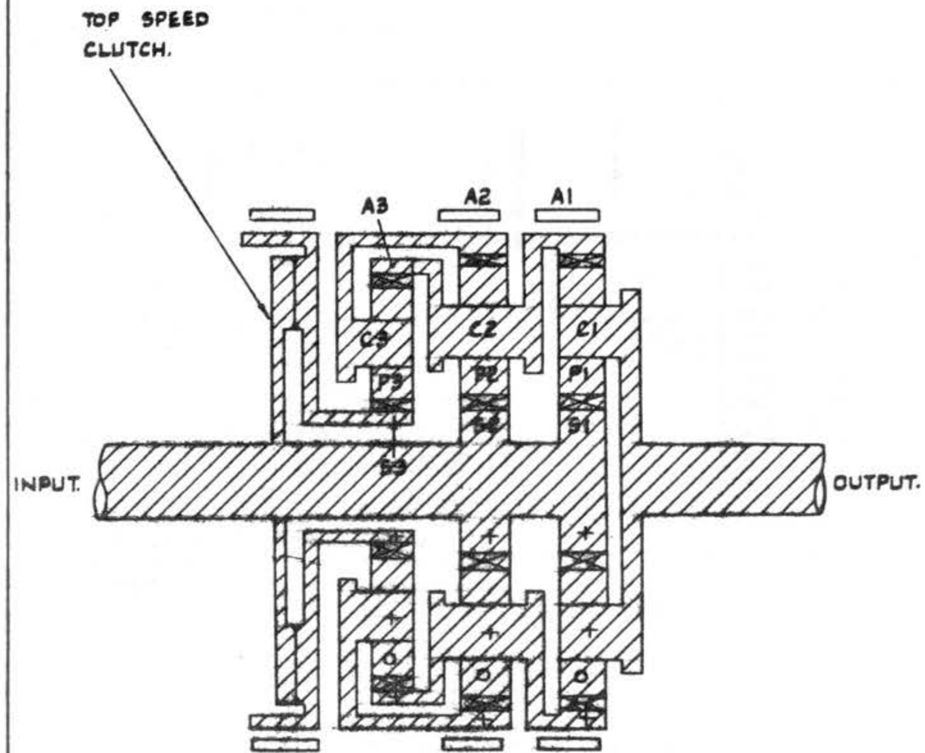
ROTATION.

+ CLOCKWISE LOOKING ON INPUT.

— ANTI-CLOCKWISE LOOKING ON INPUT.

O NO ROTATION.

EPICYCLIC GEARBOX
3RD SPEED ENGAGED. FIG 14



ITEMS TRANSMITTING TORQUE.

ITEMS NOT TRANSMITTING TORQUE.

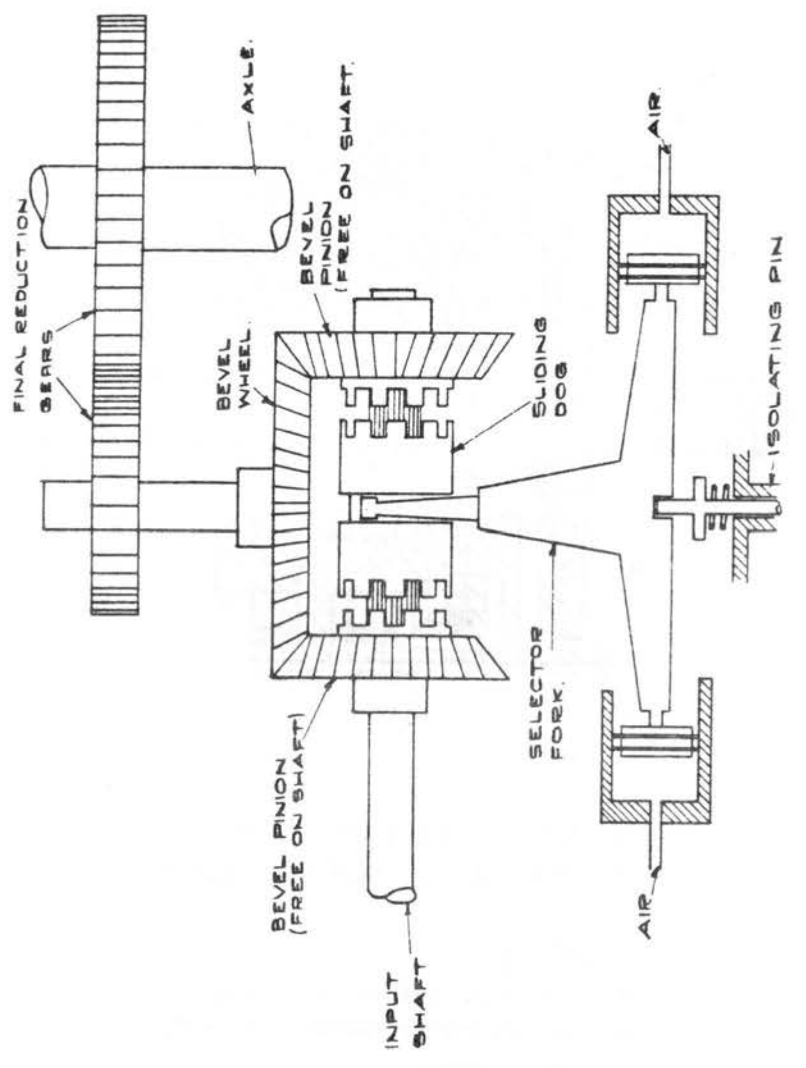
ROTATION.

+ CLOCKWISE LOOKING ON INPUT.

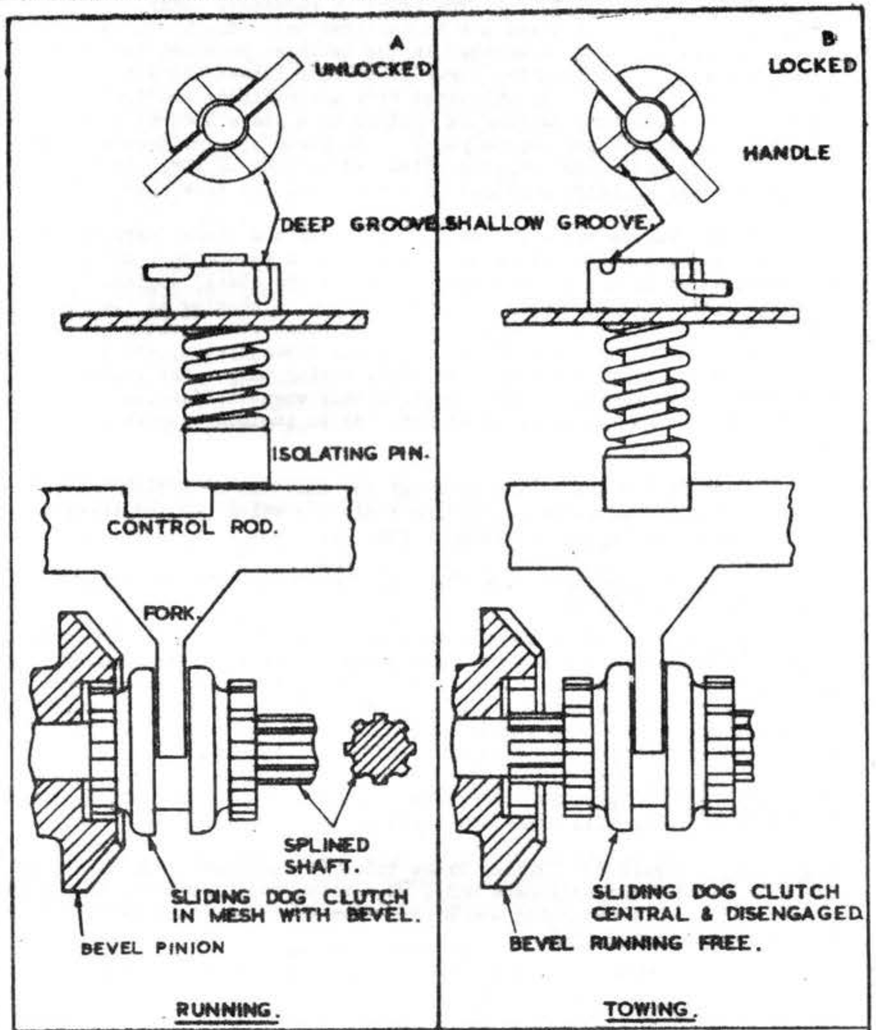
— ANTI-CLOCKWISE LOOKING ON INPUT.

O NO ROTATION.

EPICYCLIC GEARBOX.
4TH SPEED ENGAGED. FIG 15



FINAL DRIVE. FIG 16



ISOLATING & NEUTRAL LOCKING ARRGT. 36
FIG 17

VACUUM BRAKE QUICK RELEASE SYSTEM.

The operation of the Standard Vacuum brake is dependent on the creation and maintenance of a suitable vacuum in the brake cylinder above and below the piston when the brake is released. When a brake application is required air is admitted below the piston and the difference in pressure created in the cylinder provides the force to apply the brake. When the brake is to be released the air recently admitted has to be exhausted from the cylinder and train pipes. The exhausting devices as applied to a steam locomotive is the steam ejector or the vacuum pump. The steam ejector incorporates the brake application and release valve and as long as steam is available brake creation application and release can take place.

When the Vacuum brake system is applied to the Diesel Mechanical rail car, exhausting has to be done by a form of vacuum pump called an exhauster which is a vane type pump driven by the diesel engine. When the rail cars are stationary the diesel engine is running at "Idling" speed and the exhauster is working at a low rate, consequently it is not able to quickly exhaust the air from the brake system, and the brake will not be speedily released. To avoid having to run the engines at a fast rate to release the brakes, particularly when standing in stations, the Standard brake system has been modified to include a quick release feature.

The modified brake system includes the addition of a High Vacuum reservoir (A) a feed valve (B) and an isolating valve (F) and these are arranged as shown in the diagrams on page 24.

The principle of operation which can be followed by reference to the 5 diagrams is as follows:-

Running Position (Figure 1) With the exhausters (E) running at normal speed, vacuum conditions are maintained throughout the system and the feed valve (B) ensures that the vacuum in the train pipe side is reduced to 21" Mercury at which it closes. No vacuum relief (snifting) valve is provided and the exhauster continues to create the maximum vacuum it can produce, which is about 27"-28" Mercury.

"Lap Position" (Figure 2) Shows the position of the Driver's brake valve (C) to "Hold" a partial brake application.

Brake 'On' (Figure 3) Turning brake valve (C) as shown, admits air to the train pipe and brake cylinders only, preserving high vacuum in the release chamber (A). By returning the brake valve to "lap", this degree of braking can be maintained.

"Quick release position" (Figure 4) Brake valve (C) is returned to the running position and the air pressure causes feed Valve (B) and Isolating valve (F) to open. The air from the brake cylinder and train pipe flows rapidly through the open valves (B) and (F) to release chamber (A) which is large enough to accept all the air in the system. As soon as the pressure on the train pipe side of valve (B) reaches 21" Mercury (B) closes. It will be seen that during this release the exhauster was not used and, therefore, did not affect the speed of brake release. Since the brake is now released the train can move away and the exhauster can re-create the 27" - 28" Mercury Vacuum in the release chamber during the journey.

Figure 5 Shows the operation of the isolating valve (F) which prevents the vacuum in the release chamber falling below 18" or 19" Mercury. This, in effect, reduces the time taken to recharge the chamber.

From the above it can be seen that the high vacuum release reservoir is the means by which quick release of the brakes is made possible. It is, therefore, important to avoid "frittering away" this high vacuum by making repeated partial applications and releases when stopping.

The "lap" position enables the driver to hold any degree of braking without passing air back to the exhauster.

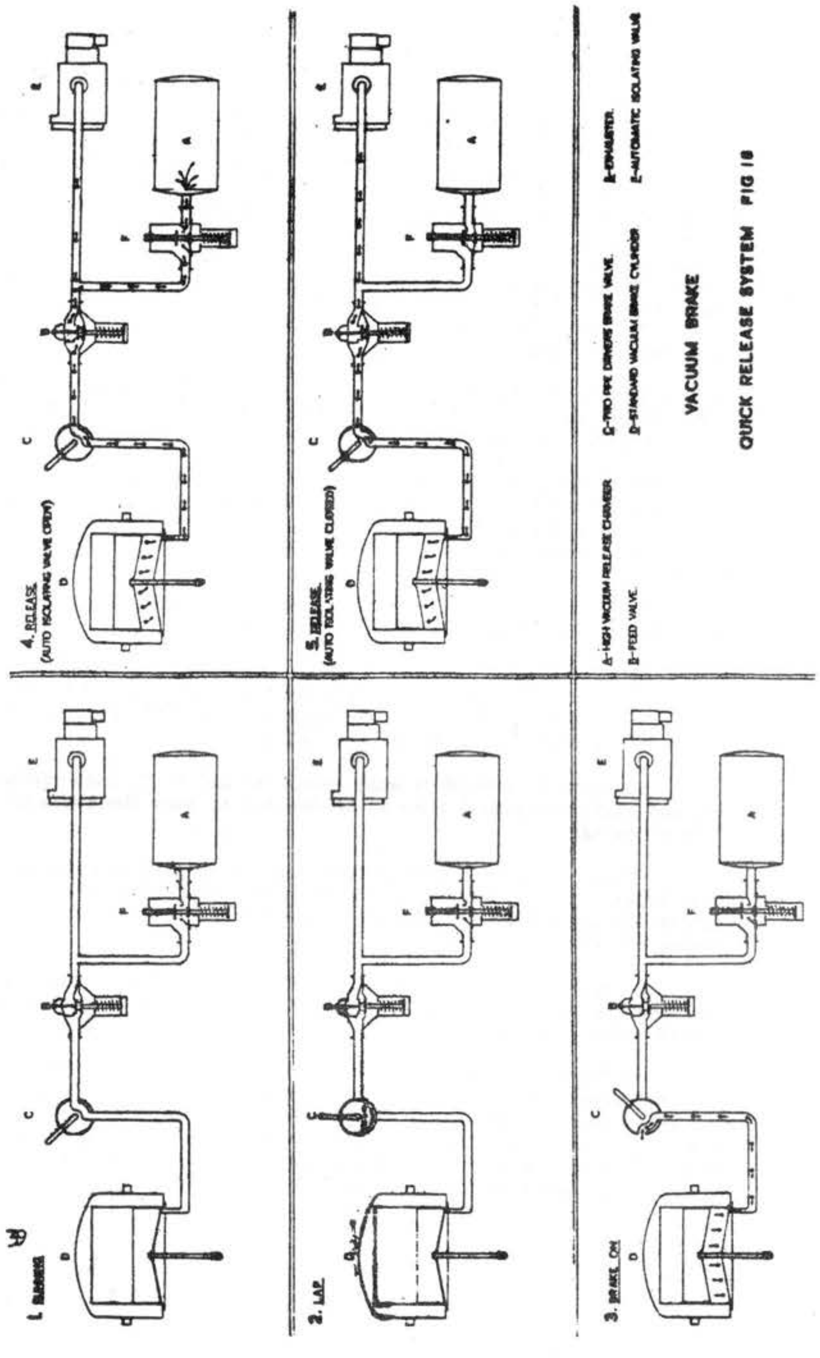
Drivers should drop the train pipe pressure to a pressure dependent upon circumstances and experience and move the brake valve handle back to lap to hold the brake application. Moving beyond 'lap' to 'release' floods the reservoir with air.

The correct procedure will result in 28" - 29" high vacuum being preserved until the moment when it is desired to ease the brake off just before stopping.

Provision is made in the brake system to give Deadman operation of the brake, through release of the throttle lever energising an electrically operated valve and also the usual facility of the Passenger operated emergency braking.

In order that the driver may move to the other side of his cab to observe signals, etc., the Deadman's brake application is delayed for 5 seconds after releasing the throttle lever by a dashpot device.

At the other side of the cab a push button is provided which whilst depressed prevents the brake application from taking place. After releasing the button a 5 second delay allows the driver to return to his seat and resume driving. Whilst the throttle handle is released the engine will continue to run at idling speed, the freewheel operating and car speed altering according to load and gradient.



VACUUM BRAKE

QUICK RELEASE SYSTEM FIG 18

There are two vacuum pipes running the length of the train. The train-pipe which is painted black, and has a standard hose coupling, and a release pipe which is painted blue. This pipe has the lugs on the hose couplings reversed to avoid coupling the pipes wrongly.

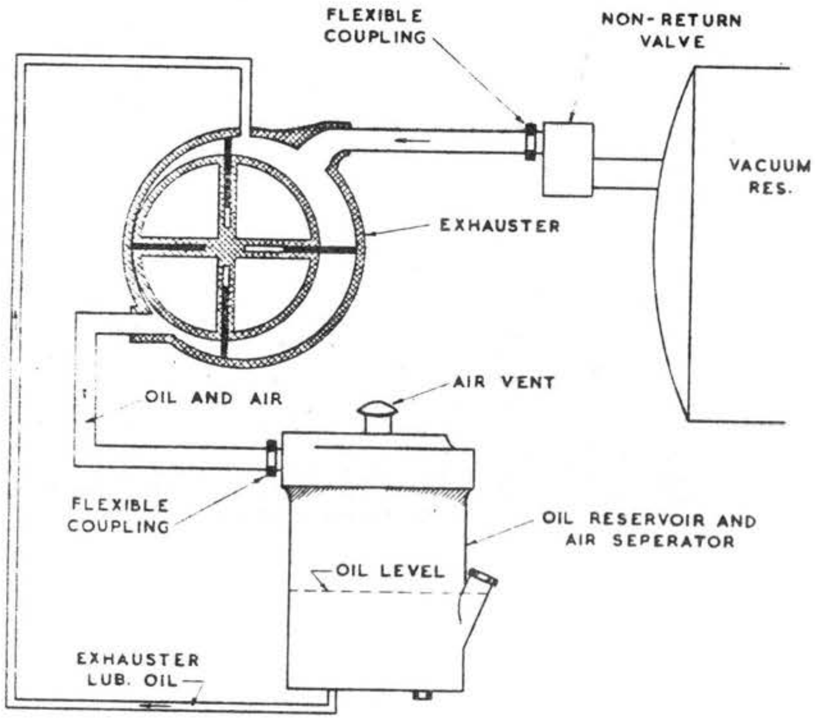
The Driver's brake valve handle is detachable only in the "lap" position to ensure that there is no connection between the two pipes anywhere on the train, except in the driving cab in use.

Should a railcar be assisted by a locomotive, the vacuum pipes can be coupled and the brake operated in the normal way, but all deadman valves will have to be isolated. Should this isolation not be possible, the battery switch must be placed to "on", and the throttle handle held down.

EXHAUSTERS

The two exhausters, one to each engine, are of the rotary sliding vane type, the rotor and blades being eccentric to the body. As will be seen in the diagram, the space between the blades will increase and decrease as the blades rotate so that air will be drawn from the system, compressed as the space diminishes, and be expelled to atmosphere via the oil reservoir.

The oil reservoir provides lubrication for the exhauster, the vacuum in the body drawing oil from the reservoir via the lubricating oil pipe to the banjo union where it is atomised on entering the exhauster body, it will then be carried by the air being expelled, back to the oil reservoir where it is separated. The air being released to atmosphere and the oil passing to the bottom of the reservoir.



EXHAUSTER LUBRICATION FIG 19

CONTROL.

The driver's controls consist of a combined throttle control and "Deadman" handle on the left of the control table and a gear-change handle with the Forward & Reverse lever on the right.

The movement of these controls will energise the various E.P. valves by supplying current from the batteries or, when the engine is running, from the generator. The E.P.valves will then allow the passage of compressed air to operate the throttle motors, engage the forward or reverse gears in the final drive units, and the epicyclic gearbox pistons.

Final Drive Control

Current from the batteries will pass via the engine isolating switch and battery switch to the Reverser in the cab, from which it is directed to either the Forward or Reverse E.P.valves. Branches from these wires will pass through the Train Lines and Jumper Cables to the appropriate E.P. Valves on the other power cars.

To reverse the direction of travel the sliding dog has to be moved from one side to another, and held there by compressed air acting on one or other of the pistons. This air is supplied from the main reservoir via the Forward or Reverse E.P.Valve.

The Gearbox Control

Gears are selected by admitting air to the cylinder of each gear to enable the brake band in the case of 1st,2nd & 3rd gears and the clutch in the case of 4th gear to operate. This air is supplied from the main reservoir via the gearbox E.P. valves and the current to energise the valves will come from the batteries via the gear selector handle.

To ensure that the Gearbox will return to "neutral" should the "Deadman" be released the current is supplied to the gear selector through contacts on the throttle control. Mechanical interlocking ensures that the gear selector can only be moved from "neutral" when the reversing lever is at "Forward" or "Reverse" and the reversing lever can only be moved when the gear selector is in "neutral".

Air Pressure Switches

These are used to indicate electrically that a safe minimum air pressure has been obtained and that the Final Drive Dogs are engaged. This indication is seen by the "Air & Axle" lights being illuminated.

CONTROL (CONTINUED)

Oil Pressure Switch

This Switch is mounted on the engine and is used to indicate the lubricating oil pressure. Whilst pressure is normal the engine light on the control panel will be illuminated but should oil pressure fall to a dangerous level the light will be extinguished and the Pressure Switch will energise the Engine Shut Down Solenoid; this will in turn cut off the fuel supply to the engine.

Battery Isolating Switch

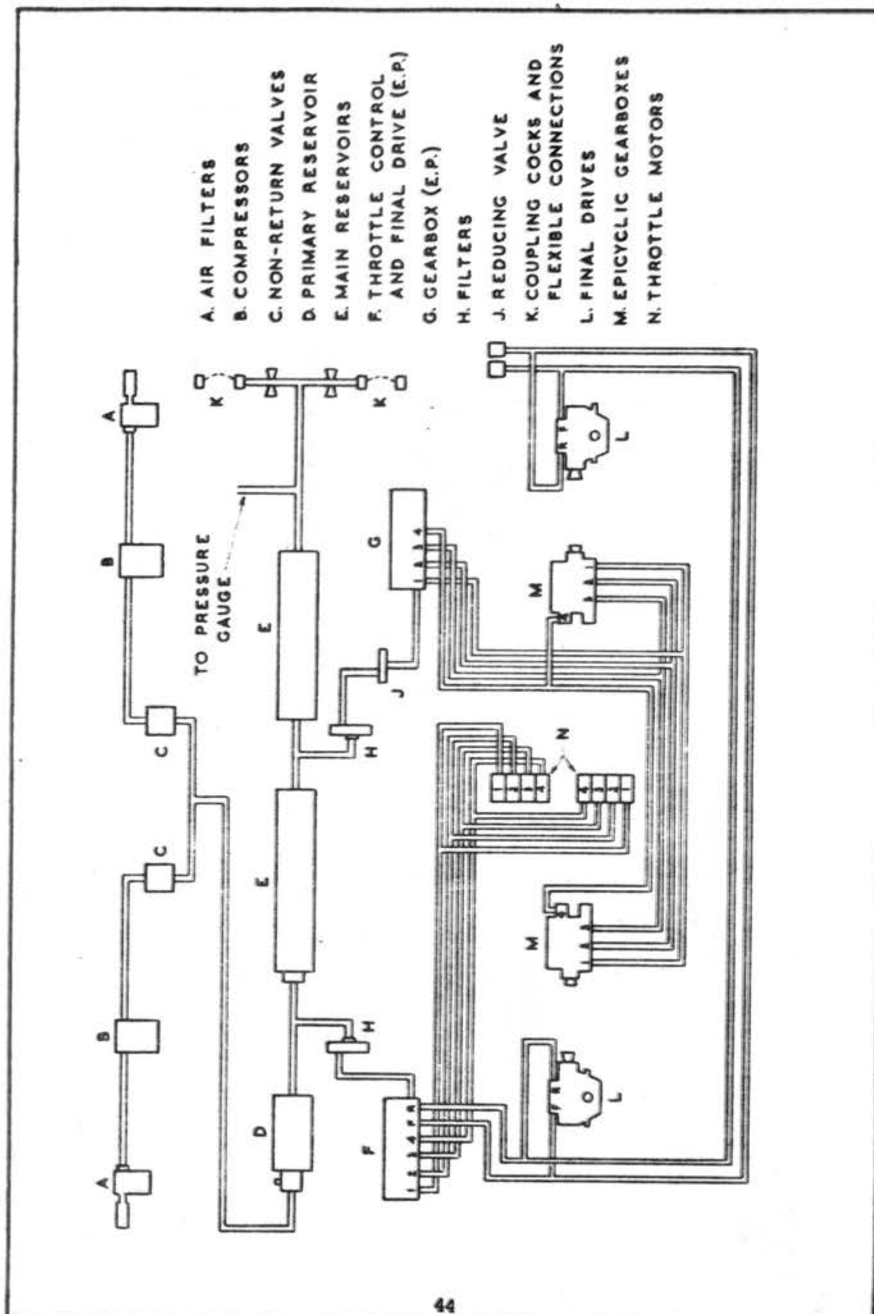
This Switch when open will isolate the battery from all circuits on the car, therefore, the driver should ensure that this Switch is closed when preparing the car for service, and opened when berthing, to ensure that no leakage of current can occur.

Engine isolating Switch.

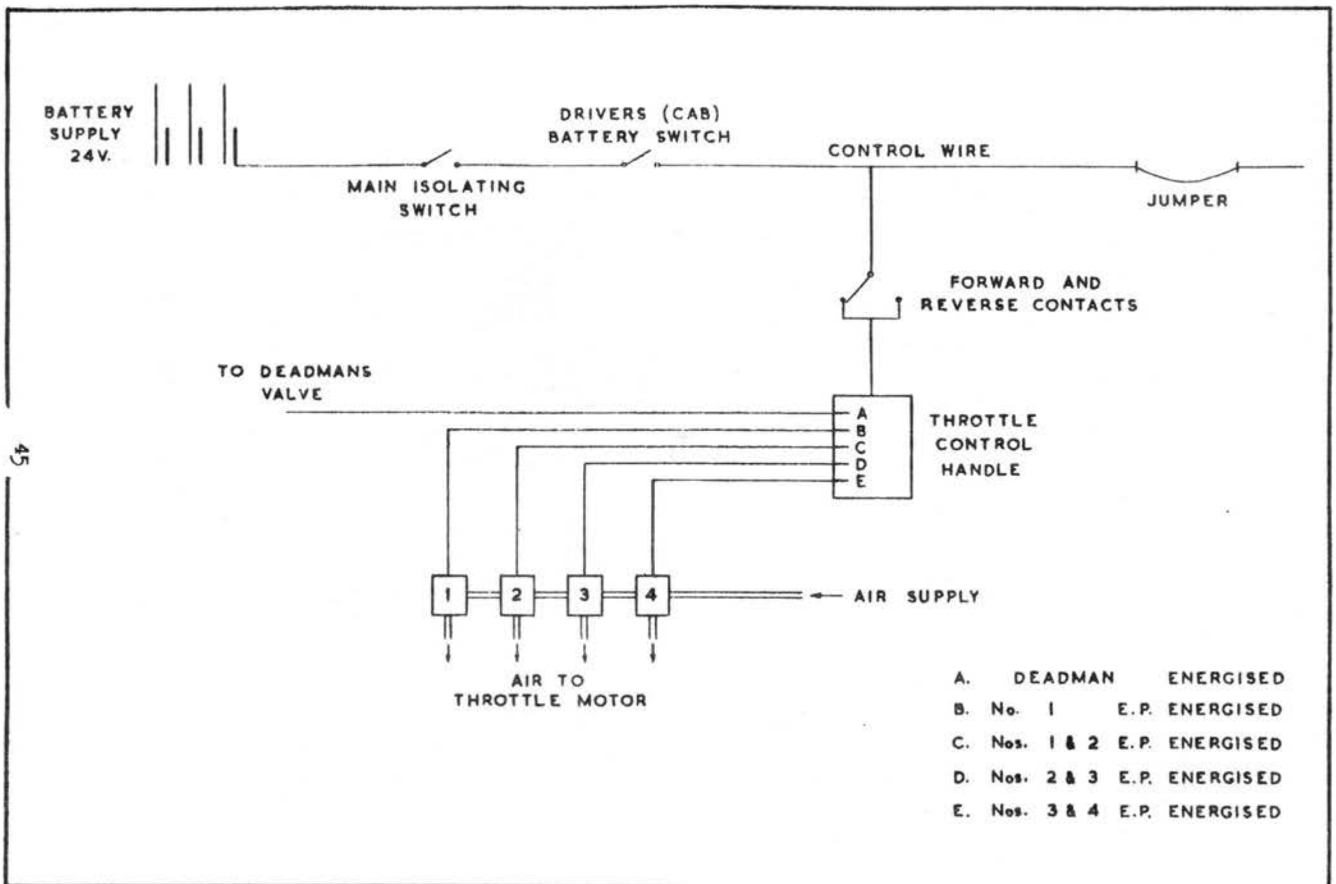
This Switch is operated by a carriage key and is used to isolate an individual engine in the event of a failure of that engine or its transmission.

Engine Local Control Box

This is situated on the side of the car adjacent to each engine and is provided in order that engines can be started or stopped from the ground. It consists of two start and two stop buttons, one each for numbers one and two engines. It must be remembered that an engine that is started locally must be stopped locally, before starting all engines from the cab.

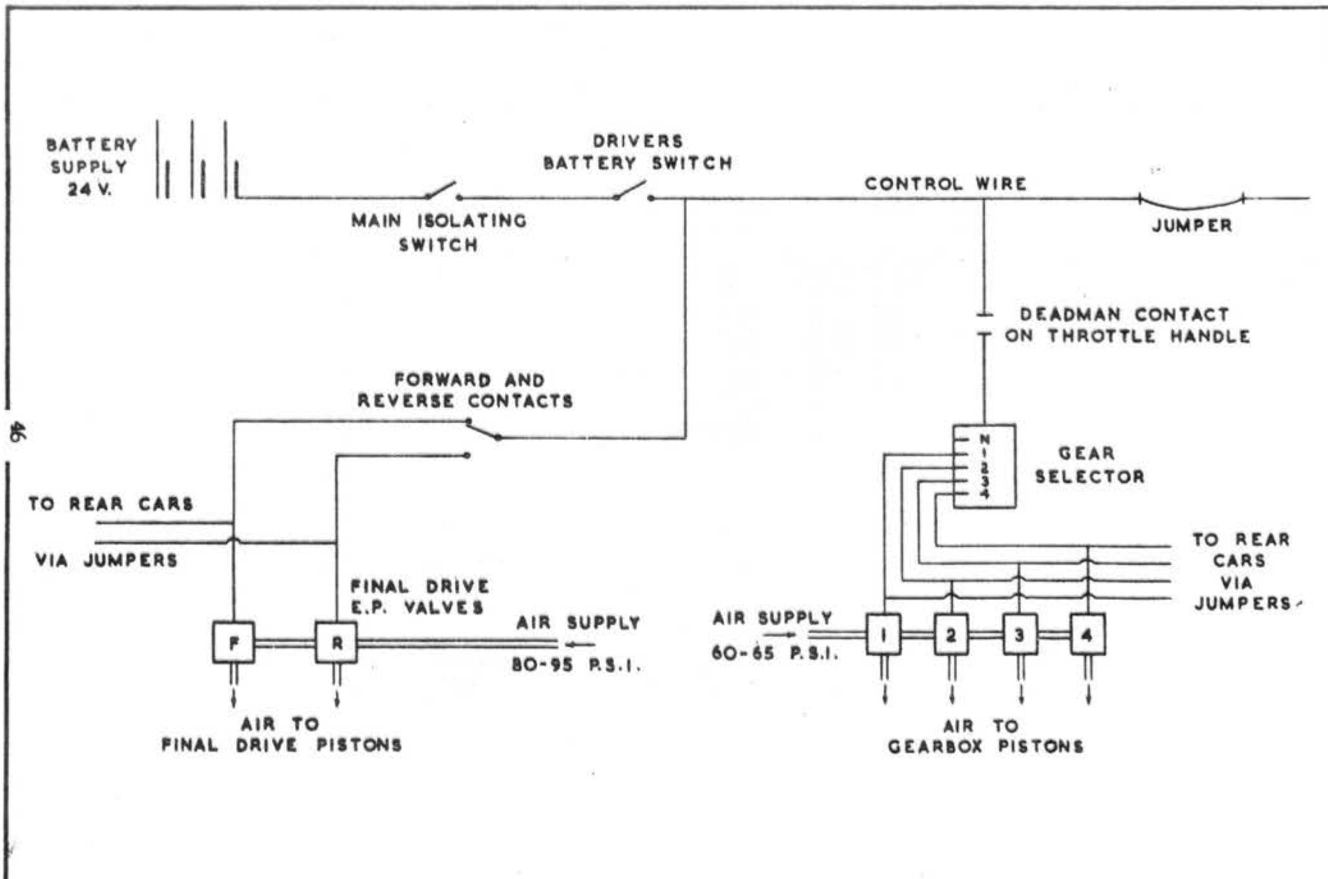


AIR CONTROL SYSTEM FIG 20



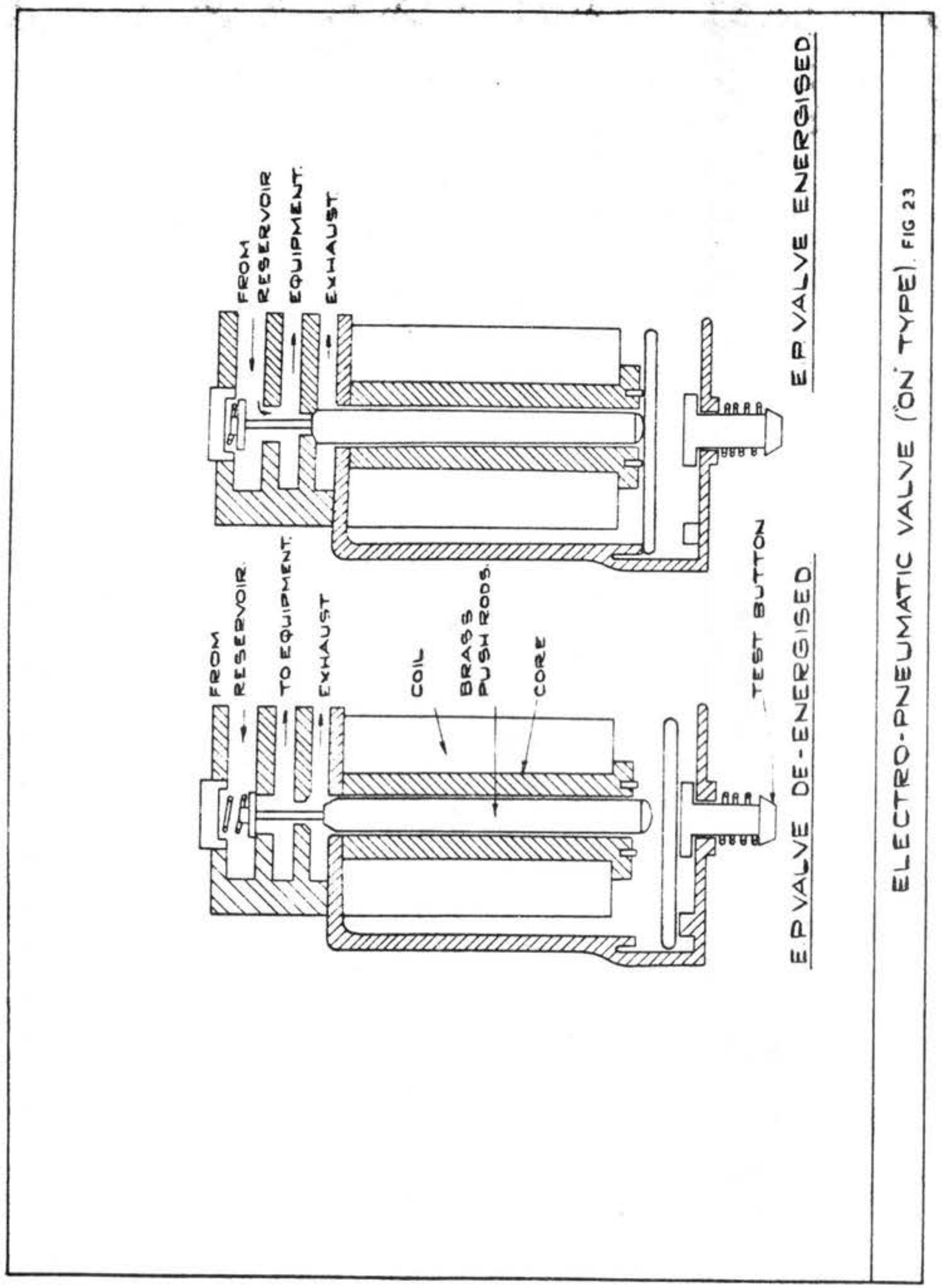
ENGINE SPEED CONTROL FIG 21

45



GEARBOX CONTROL FIG 22

46



ELECTRO-PNEUMATIC VALVE ('ON' TYPE) FIG 23

THE COMPRESSED AIR SYSTEM.

Each Power Car is fitted with two Compressors, one mounted on and gear driven by each engine.

Air is drawn through a Filter and Anti-freeze unit which introduces a small quantity of spirit into the air to prevent any moisture freezing in the system.

From the Compressor the air passes via Non Return Valves to a Primary Reservoir where it is stored at a pressure of 80 to 95 p.s.i.

As the Compressor will run continuously while the engine is running, some means must be found to control the maximum pressure, this is the purpose of the Unloader Valve, which is situated on the end of the Primary Reservoir.

Located above the Unloader Valve is a Safety Valve which is set to vent the air at 100 p.s.i. should the Unloader Valve fail.

From the Primary Reservoir air is fed to the (a) Throttle E.P. Valves and (b) Final Drive E.P.Valves, it will also pass through the Diverter Valve into the two Main Reservoir Tanks and via a Reducing Valve set at 60 - 65 p.s.i. to the Gearbox E.P. Valves and to the Train-Pipe.

The Diverter Valve is fitted because, when the engines are cold and there is no air pressure in the system, the Throttles must be held open by hand until sufficient pressure has been built up to operate the Throttle Motors. This period is considerably reduced by the Diverter Valve which seals off the Large Main Reservoir Tanks until 50 p.s.i. has been built up in the Primary Reservoir and is available to operate the Throttle Motor and hold it at idling speed.

If pressure were lost, due to a broken pipe between the Diverter Valve and the Train Pipe, the gauge in the cab would drop to zero but as the Diverter Valve would close at 50 p.s.i., this pressure, trapped in the Primary Reservoir, would be sufficient to isolate the Final Drive. Therefore, in the even of loss of pressure, it is advisable to try to isolate even if the pressure gauge registers zero.

THE DEADMAN'S VALVE.

The Deadman's valve in each driving compartment is energised via contacts in the throttle handle of the leading cab, which are closed when the handle is depressed.

The valve as will be seen from the diagram is actually two valves, one, a Control Valve consisting of an Electro Magnet, a diaphragm and a double ended piston valve. The other an Emergency Valve containing a spring loaded valve and diaphragm.

With the throttle handle depressed the Electro Magnet is energised causing the piston to lift thus keeping the upper port open and the lower one closed. This connects the timing Chamber and the underside of the Emergency valve diaphragm to the Vacuum train pipe, therefore there will be train pipe vacuum above and below the Emergency Diaphragm and the valve will be held down by the spring.

Should the throttle handle be released the Solenoid will become de-energised and atmospheric pressure above the diaphragm in the Control valve will force this valve down, thus the upper port will close and disconnect the timing chamber from the train pipe. The lower valve will open allowing atmospheric pressure to enter the timing chamber via the passage to the underside of the Emergency Diaphragm. However, due to the small diameter of the passage between these two, a time delay of 5 - 7 seconds will occur before the Emergency Diaphragm will lift, as pressure has first to be built up in the timing chamber itself.

When pressure has built up beneath the Emergency diaphragm it will lift and force the valve open allowing atmosphere into the train pipe, when,however, the pressure above and below the Emergency diaphragm equalises the valve will close.

An isolating cock is fitted to the deadman's valve in each cab and when operated will connect the timing chamber to the train pipe, isolate it from the control valve, and render it inoperative.

A button is fitted to the opposite side of the cab and the time delay will allow the driver to cross from one side to the other and depress the button to keep the solenoids energised before the brakes apply.

THE UNLOADER VALVE.

As the compressor is gear driven from the engine, it runs contiñuously whilst the engine is running. When the maximum pressure is reached in the main reservoir the compressor must be unloaded i.e. the air that it compresses must be returned to the atmosphere instead of passing into the main reservoirs.

The Unloader Valve consists of a verticle piston and valve as shewn. Above the piston is an adjustable spring which determines the unloading pressure, and below it are the operating bellows. A spring loaded check valve prevents air from returning from the small reservoir.

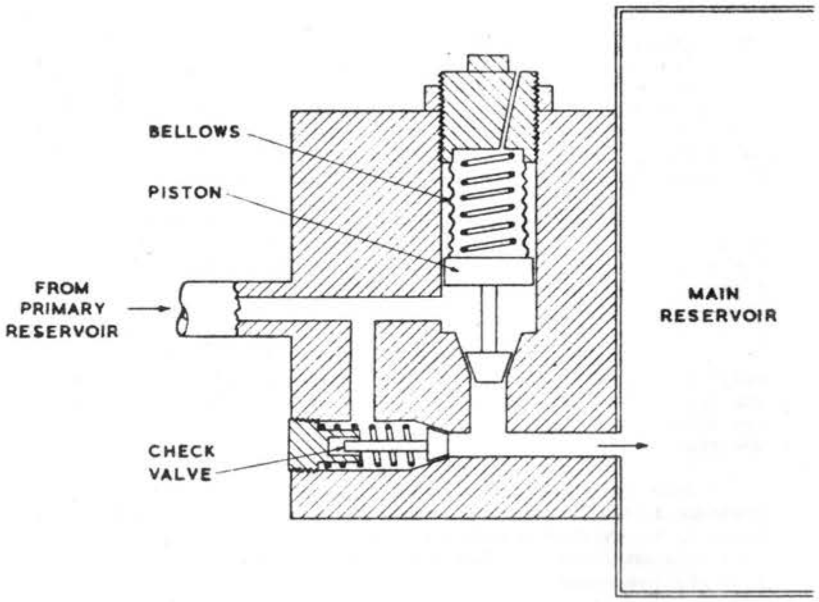
When the main reservoir air pressure is below maximum, air from the compressors enters at the left side and flows to the small reservoir via the check valve. Air from the reservoir also passes to the inside of the bellows but these are held down by the pressure of the spring on the piston.

When the reservoir pressure reaches 95 p.s.i. the upward pressure in the bellows overcomes the spring pressure and the valve moves up to its open position. Air from the compressors can then pass to atmosphere. The check valve prevents the escape of air from the reservoir.

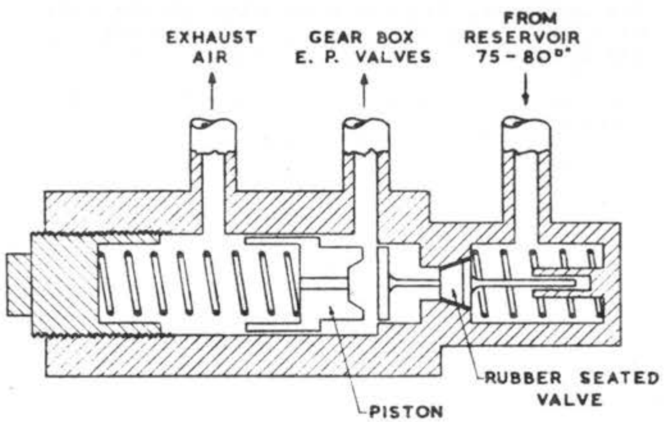
When the reservoir pressure drops to 80 p.s.i. the spring overcomes the pressure in the bellows and the valve seats. Air from the compressors then passes to the reservoir again.

If the valve were to stick open, or the bellows leak, the pressure would be lost and the blanking off cap, which will be found on a nearby stud should be screwed onto the air outlet. This prevents the unloader valve from operating and the reservoir pressure will then be limited to 100 p.s.i. by the safety valve.

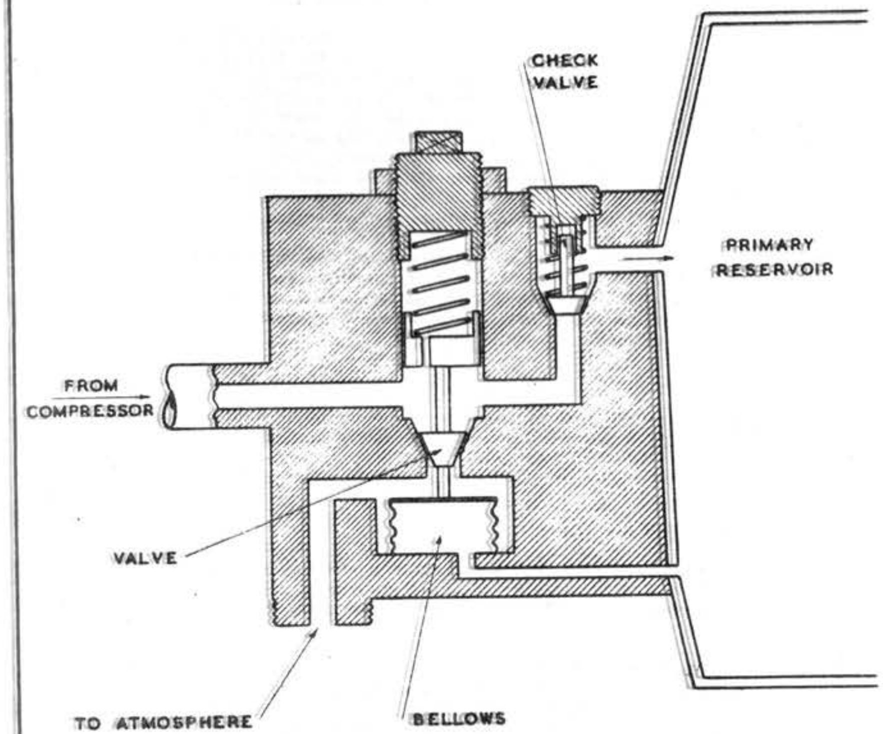
During preparation the driver should check that the blanking off cap is on the stud and that it can be turned by hand.



DIVERTER VALVE FIG 24A



REDUCING VALVE FIG 24B



UNLOADER VALVE
FIG 25

AUTOMATIC FIRE ALARM SYSTEM.

Automatic Fire protection is provided in each engine bay of the underframe, and is operated by a thermostatic detector which, in the event of a fire or high temperature, will discharge a chemical extinguisher.

Indication of a fire will be by means of a warning bell sounding in the Driver's cab and a Red Warning light will be exhibited on the Fire Alarm Control box adjacent to the affected engine.

When the fire alarm bell rings, the Driver must bring the train to a stand and taking a hand extiguisher with him inspect the affected engine as indicated by the Warning light.

Upon ensuring that the fire has been extinguished, the Driver must pull off the metal tab on the front of the Fire Alarm Control box and operate the small switch which will be exposed. The operation of this switch will stop the Alarm bell ringing, extinguish the Red Warning light and render it impossible to restart the engine, but it must be remembered that the Alarm isolating switch does not cut out the thermostat which is automatically reset, therefore if a fire should recur on the same engine, the Fire Alarm bell will again ring and the Warning Light will again be exhibited but there will be no automatic extinguisher in operation on that engine.

In the event of a fire on any engine, the Final Drive associated with that engine must be isolated if possible, failure to isolate the Final Drive will restrict the maximum speed of the train to 25 m.p.h. until it is possible to detach the defective unit and take it out of service.

NOTE : The chemical discharged by the automatic extinguisher gives off a gas which can be harmful if inhaled in quantity, also avoid touching the liquid with the skin or clothes, therefore care must be taken when examining the engine.

FIRE CONTROL CIRCUIT

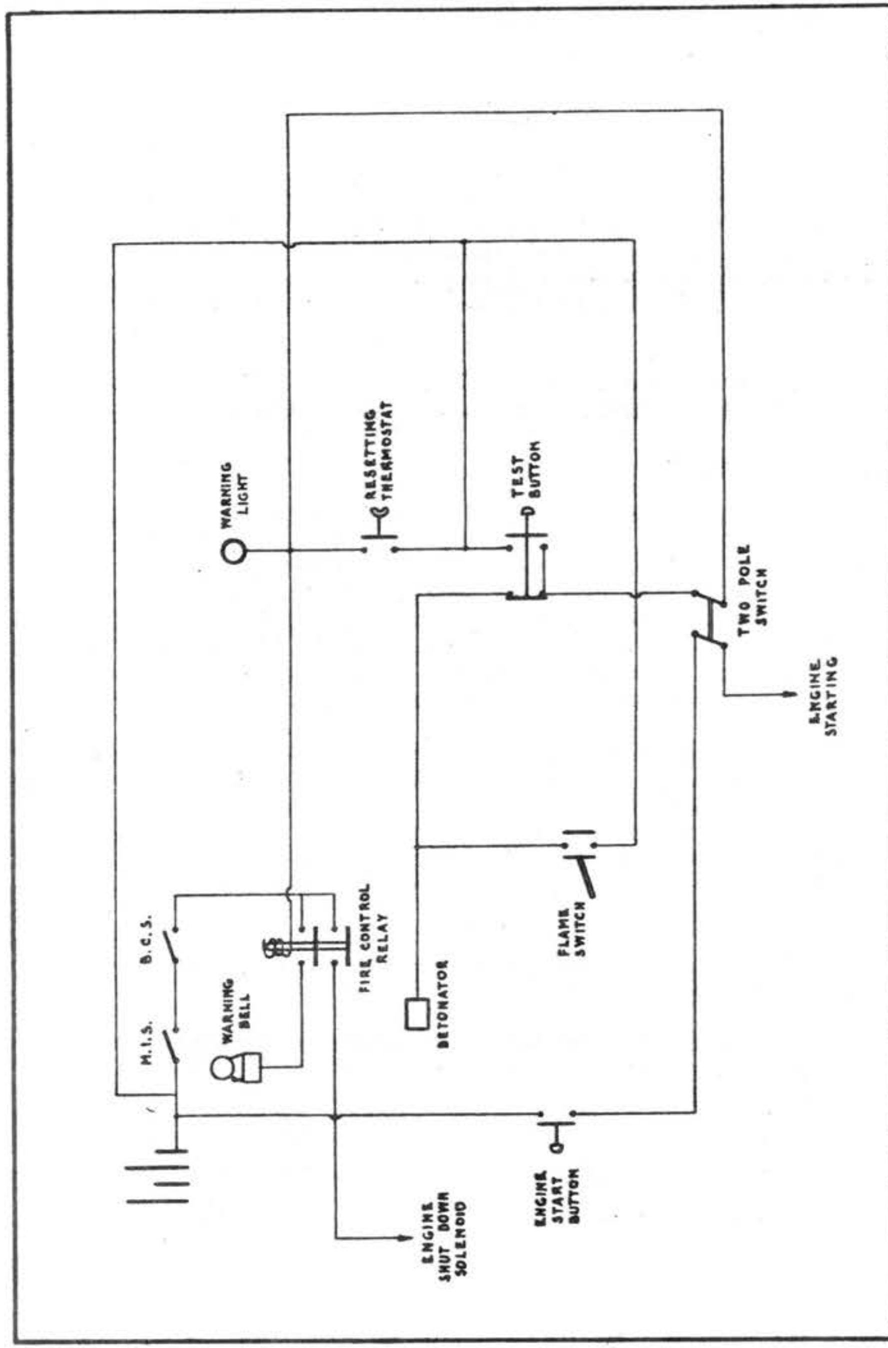
As will be seen from the diagram a constant supply from the battery is fed to one side of the Flame Switch, the other side is fed two ways, one to the Detonator and the other to the Fire Control Relay.

The FlameSwitch is operated by an Explosive Wick situated within the Capillary Tube. At abnormal temperatures the closing of the Flame Switch will pass the current to the Detonator under a gas (CO_2) bottle and a heavy gas will be released to "blanket" the engine. At the same time, the current passes via the Two Pole Switch; illuminates the Warning Light which is situated on the Fire Control Panel and also energises the Fire Control Relay.

The energising of the Relay allows the current to pass from the battery via the Main Isolating Switch and the Battery Control Switch to ring the Warning Bell in the Cab and to operate the Engine Shut Down Solenoid.

When the fire has been extinguished the Metal Tab over the Two Pole Switch must be pulled off and the Switch operated; this will have the effect of extinguishing the Warning Light and de-energising the Relay, thus stopping the Bell from ringing.

The operation of the Switch will also isolate the engine starting circuit so preventing the engine from restarting.



FIRE CONTROL CIRCUIT FIG 26

SMITH'S HEATERS.

Heating for the interior of the coaches and driving Compartments is provided by a Smith's Heater.

These heaters are of the Combustion type. Fuel oil is sprayed into the Combustion Chamber where it is burnt. Air is drawn in by an electrically driven fan and by the heat exchange principle, which means that heating is separate from combustion air, air is heated as it passes over and around the Combustion Chamber and the heated air is blown into the compartments through under seat ducting.

The Heaters are underslung on the frames of each coach and controlled electrically from independent panels on each car.

Method for starting the heaters.

Turn the Heater switch in a clockwise direction to the "Starting" position. This will supply current to the "Glow Plug" light. (Should the light not become illuminated, return the switch to "off" and do not restart). After approximately 45 seconds the "Airfan" light should become illuminated indicating that the heater fan and fuel pumps are working, after 3½ minutes the "Glow-Plug" indicator light will be extinguished and the switch should then be turned anti-clockwise to the "Running" position.

If, for any reason, the "Airfan" light should not become illuminated in the "Start" position, or the "Airfan" light becomes extinguished while the switch is in the "Running" position, the switch should be returned to the "Off" position and the heaters restarted. Not more than three attempts should be made to start the heaters.

To switch the heaters off, the switch on the Control panel must always be used. The Main switches should not be used until at least 5 minutes afterwards.

The control panel on some cars varies and requires a different method of operation which is as follows:-

Turn the switch to "Full heat", after 3½ minutes the heat light will remain illuminated and the "Glow Plug" light will be extinguished.

PREPARATION.

~~Obtain the satchel containing the Control Switch key, reversing lever, Vacuum brake handle and carriage keys.~~

ALL CABS

(1) Check cabs for Detonator cases, flags, etc.

(2) Check that the Deadman isolating covers are in position.

(3) Lock all doors of driving compartments not in use.

(4) Check that all handbrakes, except that in the leading compartment, are off.

IN DRIVING CAB.

(5) Turn Control switch key to "On" and check that the gear-selector handle is in "Neutral".

(6) If there is less than 65 p.s.i. available in the air system engines should be started individually. (See Local Starting Procedure at foot of this page).

(7) Check that all the "Air-Axle" indicator lights have become illuminated, indicating that the Final Drives are engaged. If not, with the engines idling, move the reversing lever to the opposite position and back again.

If an engine does not start, i.e. the indicator light does not light within 3 second, release the "Start" button and allow the engine to come to rest before pressing the "Start" button again.

Should an engine still not start, check that the Engine isolating switch is in the "ON" position, fuel tank gauge for fuel and that the fuel cock is open.

The following is the procedure for local starting

Pull the Fuel injection pump handle to the full open position and press the "Start" button on the small panel adjacent to the engine, release as soon as the engine fires. Release the Fuel Pump handle gradually until the engine idles.

Start the other engines in a similar manner, When the air pressure has built up to at least 75 p.s.i. "Stop" the engines and regain the cab.

Place the reversing lever in position and move to either the "Forward" or " Reverse" position.

Depress the throttle handle and move to the 1st or 2nd throttle position, then press left and right "Start" buttons in turn.
Release the button immediately the indicator lights show that the engines have started.

When all engines are running, return the throttle handle to the idling position.

DISPOSAL.

(1) Return the throttle to the "Idling" position and release the Deadman.

(2) Check that the vacuum brake is on.

(3) Press the engine "Stop" button until all lights are out.

(4) Place reversing lever to "Neutral".

(5) Apply Handbrake.

(6) Place vacuum handle to lap position and remove.

(7) Remove reversing lever.

(8) Turn Control key to "OFF" and remove.

(9) Shut off heaters if in use.

(10) Lock driving compartment doors. Return satchel and keys to authorised place.

PROCEDURE FOR ISOLATING ENGINES AND FINAL DRIVES.

Place reverser in "Neutral".

Stop all engines.

Isolate defective engine by turning engine isolating switch to "Off" with carriage key.

Using isolating fork (carried in Guards compartment), turn isolating plunger to horizontal position.

Select "Forward" and "Reverse" with reversing handle in cab, 3 or 4 times to allow plunger to engage.

Manually test cardan shaft for free movement, indicating that the drive is locked in "Neutral".

It is not possible to isolate final drives if no air pressure is available. After isolating engines, close all isolating cocks on defective car and proceed at not more than 25 m.p.h. until defective car can be detached.

FAULTS AND FAILURES D.M.M.U.

(1) ENGINE WILL NOT CRANK (when using "Local Start" Button).

Check that ~~Battery~~ Control ~~Switch~~ Key is turned to "ON".
Check Battery Indicator Light illuminated. CONTROL LIGHT
Check Engine Isolating Switch at "ON". LOW WATER & 2 POLE FIRE SWIT

(2) ENGINE WILL NOT CRANK (when using "All Engine Start" Button).

Check ~~Battery~~ Control ~~Switch~~ Key at "ON".
Check ~~Battery~~ Indicator Light illuminated.
Check Reverser Handle in "Forward" or "Reverse".
Should an individual engine not start when using "All Engine" Button, endeavour to start using "Local Start" Button.

(3) ENGINE CRANKS BUT WILL NOT FIRE.

Check fuel tank content.
Check Fuel Stop Cock.
Check engine sump for lubricating oil level.
Check radiator water level.
Check for air lock in fuel system by opening "Bleed" Screw and operating Hand Priming Lever.

(4) ENGINE STOPS WHILE RUNNING. (Engine Light becomes extinguished).

Check Bulb not loose in Holder.
Make not more than three attempts to restart using "All Start" Button pausing at least 10 seconds between each attempt to allow engine to come to rest.

Should engine not start

At next convenient point ascertain that engine has stopped.
Try to restart using "Local Start" Button as above.
Check fuel tank content.
Check lubricating oil level.
Check radiator level.
Should it not be possible to start an engine, ~~the final drive must be isolated and~~ the engine isolating switch SHOULD BE operated.

(5) AIR AND AXLE LIGHTS NOT ILLUMINATED.

Check air pressure (75 p.s.i.) in power car concerned.
With engine "Idling" operate Reverser Handle to opposite direction and back again.
With engines "Idling" briefly select 4th gear then return to "Neutral".
Check Pointer on Final Drives are correct i.e. opposite to direction of travel, if so proceed.
Should pointers not be in correct position.
Isolate Final Drives concerned.
Operate Engine Isolating Switches.

(6) LOSS OF AIR PRESSURE.

Check Unloader Valve and if necessary blank off.

Check for air leaks in the following manner:-

In Multiple:- Close Isolating Cocks between Units and check air gauges for defective unit.

Single Unit:- Close Isolating Cocks between Coaches and check air gauges to find defective coach, leave Cocks closed at each end of defective coach to isolate it.

Should Power Car be defective, stop both engines, operate Engine Isolating Switches and isolate both Final Drives.

(7) LOSS OF TRAIN PIPE VACUUM.

Examine cabs for defective Deadman Valve and isolate.
Check for leaks as for loss of train pipe air.
When defective car is found isolate with cocks.
Release vacuum brakes on coaches with least amount of brake power.
Drive from first available cab in half with greatest brake power, should this be the rear part of the train the Guard must ride in the leading cab and the unit must be taken from service at the earliest opportunity.

(8) LOSS OF HIGH VACUUM.

Locate and isolate defective car as for loss of train pipe vacuum.
Brakes will be operative on all cars, but should the defective car be a power car, brakes will be slower in releasing owing to the loss of high vacuum reservoirs on isolated car.
Should the high vacuum not be available in the leading car, drive from next cab in rear, guard in leading cab.
Defective unit taken out of service as soon as possible.

Should there be
(a) Pronounced knock on an Engine.
(b) Excessive smoke from an exhaust.
(c) Overheating or leaking Fluid Coupling.
(d) An engine repeatedly stops.
(e) Broken or defective Cardon Shaft.
(f) Defective or leaking Gearbox

Stop engine, ~~isolate the Final Drive~~ and operate Engine Isolating Switch. ISOLATE FINAL DRIVE FOR E&F ONLY

(9) FAILURE OF A "TRAIN" FUSE IS INDICATED BY:-
AWS HORN BLOW
Indicator Panel Light extinguished.
Engines return to "Idling".
Engine Stop Button is inoperative.
Deadman operates, applying brakes.

REMEDY

Transfer ~~Battery~~ Control Key to next cab in rear.
~~Isolate Deadman~~ and regain control in leading cab.

(10) FAILURE OF "LOCAL" FUSE IS INDICATED BY :-

Engines on defective Power Car returning to "Idling"
Deadman application on defective car.

REMEDY

The " All Engines" Stop Button will stop all except the engines on the defective car.
Manually operate Stop Solenoids and isolate engines and Final Drives of defective car.
Isolate Deadman on defective car.
Return to leading cab and start up in normal way.

(11) NO POWER TO CONTROLS.

Check Main Battery Isolating Switch is "ON".
Check ~~Battery~~ Control ~~Switch~~ Key at "ON".
Check Jumpers secure
Take Control ~~Switch~~ Key to another cab.

Where a train consists of two or more power cars, the failure of a battery on any one power car can be overcome by transfer of the control switch key to any other power car.

It will not be possible to restart the engines on the car with flat batteries therefore the engines should be isolated and the final drives locked in "Neutral".

(12) TO ISOLATE A FINAL DRIVE. (Air pressure available)

Stop engines.
Operate Engine Isolating Switch.
Obtain Isolating Fork from Guard's Compartment.
Insert Fork in Final Drive Pin Handle, pull outwards, and turn to horizontal.
Return to Cab and operate Reversing Handle six times pausing between each movement.
Check that Cardon Shaft is free to revolve by turning manually.
Restart engines and ensure that Engine and Air and Axle Lights on isolated car remain out.

Should it be found that, owing to lack of air pressure or any other reason, the Final Drive cannot be locked to "Neutral", proceed at not more than 25 m.p.h. to nearest point where unit can be disposed of.

(13) OPERATION OF AUTOMATIC FIRE SYSTEM.

Locate defective engine by illuminated Red Light on Fire Control Panel.
Ensure fire is extinguished.
Remove Tab from Panel and operate switch to stop bells ringing.
Operate Engine Isolating Switch.
~~Isolate Final Drive~~.

NOTE: The operation of the Fire Alarm Switch does not isolate the Termostat which is automatically reset, therefore should a fire re-occur on the defective engine the Alarm Bells will again ring and the Warning Light on the fire Control Panel will be illuminate.

However, due to the fact that the Automatic Fire Extinguisher has already been operated it is important that a hand extinguisher be available should the fire re-occur.